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1975 SOCIETAL COSTS OF MOTOR VEHICLE ACCIDENTS

by

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SUMMARY DISCUSSION

Motor vehicle accidents result in significant costs to individuals and to society at large. This report, which is an update and revision of a societal cost study published in 1972,[1] presents estimates of societal costs through quantification of societal loss components.

The purpose of this study is to assess some basic losses to society from motor vehicle accidents. Measurable cost components are identified to provide some indication of the scope of the human problem. However, the total of individual cost estimates of accidents should not be interpreted as the value placed on a life or as the total cost of a fatality or injury to society. Neither is it the total amount that society is willing to spend to save a life or to prevent an injury. Rather, the cost components and the total of these components are indicators of the significance of the motor vehicle accident problem.

The basic concept of societal loss is a decrease in individual and group welfare. Societal welfare is, in general terms, the sum total of individual well-being; and, in specific terms, it includes levels of health, production of goods and services (both qualitative and quantitative), personal satisfaction and happiness, and physical comfort. The concept goes beyond economic welfare. Precise specification of societal welfare would require determination of a consistent ordering of individual values and probably will never be specified in totality. In addition, quantification is not possible on all factors. The broad concept of societal welfare just described is embraced in this study with the recognition that all factors cannot be identified or measured.

[1] *Societal Costs of Motor Vehicle Accidents: Preliminary Report*, Washington, D.C., National Highway Traffic Safety Administration, April 1972.

SUMMARY OF COSTS

Application of the societal cost components and totals should be considered with this conceptual basis in mind. The primary usefulness of the cost estimates is to serve as an indication of the magnitude of the problem. Though the societal cost estimates can be useful in a benefit-cost context, it should be recognized that a benefit-cost ratio or net benefit figure is only one component of a relatively substantial array of social and technological factors that must be considered in evaluating the worth of a program.

The general approach of this study is to derive cost estimates that adequately reflect certain losses to society. Some losses are to individuals as a part of society and others are to society external to the individual. The two basic criteria for identifying loss components are (1) resources consumed in the repair of damage to people and vehicles that could be shifted in the long run to welfare-producing activities and (2) the consumption losses of individuals and society at large caused by losses in production and the ability to produce.

Costs of medical care, repair costs of vehicle damage, legal and court costs, accident investigation costs, and insurance administration costs relate to the first concept of loss. The resources consumed in these activities could be shifted to raise the existing level of economic and social welfare of society were they not devoted to "cleaning up" the damage from accidents. On the other hand, losses in production relate to the accident victim's inability to produce in the market context, in home and

family activities, and in community service. Losses in production are also related to the time spent by others in response to accident ramifications and in the delay caused by the accident to others on the road.

The current measurement does not identify the redistributions that occur between individuals as a result of an accident; nor does the quantification determine how much of a loss is compensated and by whom the compensation is provided, whether by the individual, by private insurance, or by government. Redistributions in the Gross National Product (GNP) occur as the result of accidents; in fact, the overall level of GNP may be increased by the occurrence of accidents. Therefore, in the context of losses in societal welfare, a GNP approach to measurement is neither valid nor relevant. Losses may be largely to the individual for some cost components, but these are losses to society as a whole because the individual is an integral part of society.

Costs are presented in section II by fatality, by injury (by severity levels), and by property-damage-only involvement (i.e., per vehicle). Injury costs are estimated for the Abbreviated Injury Scale severity classification system, which is discussed in section III. The societal cost components are presented and discussed individually in section IV of this report. The conceptual basis, the data, and the method of calculation for each component are described. The study represents a slightly improved cost data base since 1971,[2] but much improvement is still needed. As improved data become available, specific component cost estimates can be adjusted. Appendix D discusses future directions in accident cost research.

Most costs were estimated for 1973, since these were the latest data for most sources at the time of analysis. These costs were updated to 1975 using a range of pertinent cost adjustment factors. These factors are presented in Appendix C.

Tables 1 and 2 present the average costs per fatality and injury by Abbreviated Injury Scale (AIS) level (see sec. III), and per vehicle for property-damage-only (PDO) accidents.

[2] *Ibid.*

Table 1. Societal Costs, Summary, 1975 (Dollars)

Cost Component	Injury Severity (AIS)						
	6	5	4	3	2	1	PDO
Production/consumption:							
Market	211,820*	126,650*	55,550*	1,645	865	65	–
Home, family and community	63,545*	37,995*	16,660*	425	310	20	–
Medical:							
Hospital	275	5,750	2,250	1,095	450	45	–
Physician and other	160	5,520	2,160	525	165	55	–
Coroner-medical examiner	130	–	–	–	–	–	–
Rehabilitation	–	6,075	3,040	–	–	–	–
Funeral	925*	–	–	–	–	–	–
Legal and court	2,190	1,645	1,090	770	150	140	7
Insurance administration	295	295	285	240	220	52	30
Accident investigation	80	80	70	45	35	28	6
Losses to others	3,685	4,180	1,830	260	130	32	–
Vehicle damage	3,990	3,990	3,960	2,920	1,865	1,595	315
Traffic delay	80	60	60	160	160	160	160
Total	287,175	192,240	86,955	8,085	4,350	2,190	520

*7 percent discount rate.

Table 2. Average and Total Costs, 1975

	Fatality	Non-Fatal Injury					Average Injury	PDO Involvement
		5	4	3	2	1		
Average cost excluding vehicle damage and traffic delay, in dollars	283,105	188,190	82,935	5,005	2,325	435	1,360	45
Total	287,175	192,240	86,955	8,085	4,350	2,190	3,185	520
Number of occurrences in thousands	46.8	4	20	80	492	3,400	4,000	21,900
Total cost in billions of dollars	13.44	.77	1.74	.65	2.14	7.45	12.75	11.40

THE ABBREVIATED INJURY SCALE

The Abbreviated Injury Scale (AIS) was first published in 1971 by a joint committee of the American Medical Association, the Society of Automotive Engineers (SAE), and the American Association of Automotive Medicine (AAAM). The scale was devised in response to a research need for a consistent scale for collecting and analyzing injury severity data and, specifically, for use by multidisciplinary accident investigation teams, which were being set up by the National Highway Traffic Safety Administration. Since that time, AIS has gained acceptance in accident investigation research, and it is likely that its use will increase in the future. For these reasons it was decided that costs should be estimated for injury severity levels in the scale.

The AIS has undergone several revisions since its inception. The most recent revision of AIS[3] was done by the Subcommittee on Injury Scaling of the SAE. The scale, as it now stands, is as follows:

AIS Code	*Category*
1	Minor
2	Moderate
3	Severe (not life threatening)
4	Severe (life threatening, survival probable)
5	Critical (survival uncertain)
6	Maximum severity (currently untreatable)

[3] *The Abbreviated Injury Scale* (1976 revision), American Medical Association, Society of Automotive Engineers and American Association for Automotive Medicine, Joint Committee on Injury Scaling, 1976.

For the purposes of estimating costs in this study, the AIS constitutes the end, rather than the means. In other words, the AIS is based on life-threatening criteria rather than on cost-based criteria. Some limited cost data are currently available for the AIS; some have been specifically tabulated for this study. Data for some cost components had to be fitted into the AIS levels. The resulting cost estimates are subject to error because past and current application of the AIS has not produced a large volume of direct cost information. Studies dealing with the direct measurement of costs by AIS-level injury will improve the component estimates. An entirely new, cost-based scale, having specific correlation to the AIS, may have to be developed to improve estimates of component costs.

SOCIETAL COST COMPONENTS

The conceptual basis and the measurement of societal cost components are presented in the following sections. The basic concepts are explained in the context of the two criteria for component identification: resources devoted to accidents and production losses. Sufficient detail is presented in the calculation of each component to identify the strengths or weaknesses of the estimates.

PRODUCTION LOSSES

Losses in present and future production resulting from the casualties of highway accidents are significant societal costs. The basic concept of production loss relates to decreases in individual and group welfare. The following scenario describes the concept better than a general discussion. When a person dies accidentally, future potential production by that individual ceases;

the deceased individual no longer produces the units of production that would have been consumed by the individual and his family and by others in society. Individual and societal welfare would have been derived from that person's production. Whether the loss is largely to the individual and his immediate family or to the rest of society is inconsequential, since the well-being of each individual in society is part of total societal welfare. This is the case for persons temporarily or permanently injured as well. Measurement of the value of lost production is, in effect, only a proxy measure of these losses in societal welfare. Assigned compensation to the individual is one means to determine societal valuation of production. In this context, the quantity to be measured is average compensation in the marketplace. That an individual might be replaced by an unemployed individual is not relevant, since the quantity to be measured is the value of life activity of that individual. When a person dies prematurely or is permanently disabled, the value of life activity of that individual is lost to society.

There are two components to lost production. The first is the market or market-proxy portion, which is the measurement of the 8-hour day or 40-hour week. The second component of total production loss is those production losses in the home and community context outside the 8-hour day. (These two components of total production loss will be presented and discussed separately.)

Market and Market-Proxy Production Losses

In determining production losses due to accident fatalities and injuries, the measurement should be general enough to be applicable to the average accident casualty. To this end, the basic approach to measurement is to quantify production losses within and outside the 40-hour workweek context. The market and market-proxy production measurements relate to production within the 40-hour week.

Many efforts have been made to measure individual productivity. The major problem in any attempt to compare or to accumulate statistics on labor services has been to find a common denominator for different industries and for different sectors of the economy. For this reason, the basic standard for measuring market production has been market compensation. Despite its inadequacies, which represent institutional rigidities and discrimination, measurement of market compensation is the most practical for the present study. There are two indirect means for estimating the value of nonmarket production: opportunity costs and market costs. In a recent study for the Social Security Administration, Wendyce Brody[4] took a market cost approach to estimate the cost of housewife production by identifying equivalent market occupations and associated hourly market wages. On the other hand, opportunity costs are the average compensations forgone in the marketplace. This approach fits the motor vehicle casualty valuation better than the market cost approach, because distinctions of labor market status or occupation are rarely made in accident data files. In addition, the opportunity cost approach is generally preferable because it does not involve the problem of being comprehensive of tasks, which is a particular problem in determining compensation in the household sector.

Once the decision is made to apply the opportunity cost principle, the appropriate value of non-market production must be determined. In an article discussing opportunity cost valuation in the household sector, Reuben Gronau[5] addresses the difficulty of knowing precisely what is the compensation forgone by the individual not in the labor market. In his view two assumptions can be made: "The fraction of those people who do not work are those who are the most efficient in the home sector (i.e., those who have the highest value of time)," or "those who abstain from entering the labor force are those who are least efficient in the market sector (i.e., those who face the lowest wage offers)." The first assumption would lead to a value slightly higher than the mean wage. Application of the second assumption would result in valuation of lower-than-average wages. The valuation for the present societal cost is for all non-market production, not just for household production. Average (mean) compensation in the marketplace is used for the following reasons: (1) of the non-market employed at a given point in time, some are labor market nonparticipants and others are unemployed, and (2) there exists in this group a broad range of skill levels as well as reasons for market nonparticipation, some institutional and some personal. Therefore, for long-term analysis the population mean compensation appears to be reasonable. Mean income as opposed to mean earnings was chosen for this measurement.

[4] Wendyce H. Brody, "Economic Value of a Housewife" in *Research and Statistics Note No. 9*, Washington, D.C., U.S. Department of Health, Education, and Welfare, Social Security Administration, August 1975.

[5] Reuben Gronau, "The Measurement of Output of the Non-Market Sector: The Evaluation of Housewife's Time," *The Measurement of Economic and Social Performance*, New York, National Bureau of Economic Research, 1975.

Use of Mean Income Versus Mean Earnings

As previously stated, the concept of loss relates to production losses that translate into consumption losses of individuals and society as a whole. Nonmarket, as well as market, losses are included for a comprehensive evaluation. Mean income figures have been used to satisfy further the criterion of comprehensiveness. Income includes earnings, as well as income from all other sources. In essence, income reflects the payoff from previous earnings. In carrying out analysis of lost future production, the return on future production should be included. For comparison purposes, table 3[6] presents the relationship between earnings and income for 1974.

Table 3. Mean Earnings and Income, 1974
(Dollars)

Year-round, Full-time workers	Male	Female
Mean earnings	12,762	7,108
Mean income	13,364	7,411

Sex and Age Distinctions in Calculating the Average Productivity Loss

Although arguments have been advanced against distinguishing sex and age in calculating average productivity loss for fatalities and injuries, there are three basic reasons for distinguishing sex in the current analysis. The reasons are as follows:

- The distribution of motor vehicle fatalities by sex significantly differs from the overall sex distribution of the population. Of the total number of persons killed in motor vehicle accidents in 1975, 73 percent were males.[7]
- Once an average productivity loss is calculated, that value is applied to every victim of accidents; therefore, the criterion of equity is satisfied.
- Use of male-only income as a proxy for all productivity losses could probably not be justified for the following reason: When there is a thorough mix of men and women in what are now considered as sex-defined roles and occupations, the mean income will likely emerge somewhere between the present female and male income (including, of course, a factor for increase over time). In all likelihood, the new average productivity loss will be higher than the current average. Hence, the weighted value for motor vehicle casualties, currently weighted to males, is probably a reasonable proxy value for the population for the future. Once an average value is computed, this average is applied to all victims of accidents.

The distinction for age in analyzing productivity losses is crucial for two reasons: (1) the distribution of highway fatalities and injuries differs from the overall U.S. population age distribution and (2) productivity loss analysis for child casualties begins at an age subsequent to the age of the child when the accident occurs, i.e., when the child enters the labor force.

Fatalities

The value of lost production for fatalities is strongly dependent on the age distribution. Tables 4 and 5 present the age distribution of fatalities for 1973. It

Table 4. Direct Future Productivity Loss for 1973 Fatalities (Market)

Age Group	Number of Fatalities	Average Direct Productivity Loss, in Dollars, Per Fatality in Age Group*
0-4	2,000	103,935
5-9	2,005	127,100
10-14	2,120	175,320
15-19	9,310	201,965
20-24	8,725	237,960
25-29	5,115	244,155
30-34	3,505	229,805
35-39	2,740	213,245
40-44	2,655	172,020
45-49	2,740	156,720
50-54	2,705	120,720
55-59	2,435	79,365
60-64	2,340	31,700
Overall average direct productivity loss per fatality		184,110

[6] *Money Income in 1974 of Families and Persons in the United States*, Washington, D.C., U.S. Department of Commerce, Bureau of the Census, Series P-60, No. 101, January 1976.

[7] Fatal Accident Reporting System, Washington, D.C., U.S. Department of Transportation, National Highway Traffic

Table 5. Basic Data for Table 4.

	Year-Round Full-Time Mean Income, 1973* (Dollars)	
Age Group	*Male*	*Female*
20-24	7,581	5,552
25-34	11,691	7,287
35-44	14,179	7,293
45-54	14,416	7,207
55-64	13,288	7,248
	Sex Distribution of Fatalities, 1973** (Percent of Total in Age Group)	
Age Group	*Male*	*Female*
0-4	58.0	42.0
5-9	61.4	38.6
10-14	67.6	32.4
15-19	74.4	25.6
20-24	80.1	19.9
25-29	78.7	21.3
30-34	76.8	23.2
35-39	75.2	24.8
40-44	72.4	27.6
45-49	71.8	28.2
50-54	70.4	29.6
55-59	70.0	30.0
60-64	65.7	34.3

**Money Income in 1973 of Families and Persons in the United States*, Washington, D.C., U.S. Department of Commerce, Bureau of the Census, Series P-60, No. 97, January 1976.

**"Motor Vehicle Deaths, 1973," *Vital Statistics of the U.S., 1973*, Rockville, Md., U.S. Department of Health, Education, and Welfare, National Center for Health Statistics, 1975.

should be emphasized that although the production calculations are carried through age 64 only, the derived average value for productivity loss should be applied equally to any fatality.

Criteria for production loss analysis (Table 4).

- Begin production analysis at age 20; end at age 65.
- Make distinction based on sex for each age group.
- Increase 3 percent per year for productivity; discount at 7%.[8]
- Calculate mean full-time income (opportunity cost).
- Calculate for median age in age group.

Method of calculation. Mean full-time income figures were increased three percent per year for productivity increase. No adjustment was made for inflation. Fatalities in each age group were carried through each income age group to age 65[9]. The following is an example of calculations:

- Age 5-9 –Median age = 7[10]
  - –Begin analysis age 20
  - –Discount rate, year 13 to year 58
  - –Beginning at 20 calculate income loss for each year based on mean income figures for each age group, discount each year at 7 percent
  - –Separate calculations for male and female in 5-9 age group
  - –Total each sex and calculate weighted average
- 20-24 –Median age = 22
  - –Begin analysis year 1
  - –Discount rate, year 1 to year 42
  - –Calculate according to above

By these calculations, the stream of income for each age was developed. The totals for each age in the age group as shown in table 4 were then averaged into the overall average figure per fatality in 1973. The updated production loss figure for 1975 is $211,820.

Non-Fatal Injuries

The value of lost production for non-fatal injuries is crucially dependent on assessments of disability and impairment for each level of injury. Although estimates of activity restriction in the short term and the long term by the Abbreviated Injury Scale (AIS) system are deficient in many respects, an assessment was made for each level using the currently available sources. The following sections describe the data and the method of calculation for each AIS level.

[8]Paul De Garmo, *Engineering Economy* (4th ed.), New York, MacMillan Company, 1967, Tables XX and XXII.

[9]Average life expectancy excluding motor vehicle deaths was investigated for discrete age and in each case fell beyond age 65.

[10]The median age for each age group was determined by a special computer run which indicated fatalities by specific age. Special unpublished computer run, Baltimore, Md., Social Security Administration Office of the Actuary, 1975.

AIS 1. Tables 6 and 7 indicate the income distribution by age and sex for AIS 1 and the calculated weighted average.

AIS 2. Tables 8 and 9 present income distribution by age and sex for AIS 2 and the calculated weighted average.

AIS 3. Tables 10 and 11 show income distribution for AIS 3 and the calculated weighted average.

Estimates of disability for market and market-proxy losses, AIS 4, 5. Information on prolonged disability from serious injuries is limited, because this kind of data can only be accumulated over an extended period of time. At best, only estimates can be made. A special

Table 6. Distribution and Average Income, AIS 1

Age	Percent of Total 20–64*	Percent of Age Group* in Dollars		Annual Average Income in Dollars**		Average, in Dollars, Male and Female
		Male	Female	Male	Female	
20–24	31.1	49.1	50.9	7,581	5,552	6,548
25–34	32.9	51.2	48.8	11,691	7,287	9,542
35–44	15.9	50.8	49.2	14,179	7,293	10,791
45–54	12.6	50.0	50.0	14,416	7,207	10,812
55–64	7.5	52.6	47.4	13,288	7,248	10,425
Weighted Average						9,036

*Restraint Systems Evaluation Program, Washington, D.C., U.S. Department of Transportation, National Highway Traffic Safety Administration, special computer runs, unpublished, 1975.

***Money Income in 1973 of Families and Persons in the United States,* Washington, D.C., U.S. Department of Commerce, Bureau of the Census, Series P-60, No. 97, January 1976.

Table 7. Average Work Loss Days and Value of Loss, AIS 1

AIS 1 with:	Percent of AIS 1	Average Work-Loss Days
Hospital stay	3.2*	17.1
No hospital stay with work loss	16.8**	6.5
No hospital stay without work loss	80.0***	–
Weighted average		1.6

Loss per day:

$$\frac{\text{Weighted average income}}{\text{Weighted average days in year}} = \frac{\$9{,}036}{260} = \$35 \text{ per day}$$

Value of loss (1973) = 1.6 ($35) = $56

Value of loss (1975) = 1.6 ($40) = $65

*Unpublished special computer study, Commission on Professional and Hospital Activities, Ann Arbor, Michigan, 1975.

**John Z. Delorean Corporation, "Automotive Occupant Protective Safety Expenditure/Benefit Study," for Allstate Insurance Co., August 1975.

***J. D. Flora, J. Bailey, and J. O'Day, "Financial Costs of Automobile Accidents," *HIT Lab Reports,* Vol. 5, No. 10, June 1975.

Table 8. Distribution and Average Income, AIS 2

Age	Percent of Total 20-64*	Percent of Age Group* in Dollars		Annual Average Income in Dollars**		Average, in Dollars, Male and Female
		Male	Female	Male	Female	
20-24	30.6	58.4	41.6	7,581	5,552	6,737
25-34	28.8	60.3	39.7	11,691	7,287	9,943
35-44	17.9	52.0	48.0	14,179	7,293	10,874
45-54	14.0	51.3	48.7	14,416	7,207	10,905
55-64	8.7	46.6	53.4	13,288	7,248	10,062
Weighted average						9,274

*Restraint Systems Evaluation Program, Washington, D.C., U.S. Department of Transportation, National Highway Traffic Safety Administration, special computer runs, unpublished, 1975.

**_Money Income in 1973 of Families and Persons in the United States_, Washington, D.C., U.S. Department of Commerce, Bureau of the Census, Series P-60, No. 97, January 1976.

Table 9. Average Work-Loss Days and Value of Loss, AIS 2

AIS 2 with:	Percent of AIS 2*	Average Work-Loss Days
Hospital stay	27.9	37**
No hospital stay with work loss	72.1	16***
	100.0	21

Loss per day: $\frac{\$9,274}{260} = \$35.70$

Total loss (1973) = 21 (35.70) = $750

Total loss (1975) = 21 ($41) = $865

*Restraint Systems Evaluation Program, Washington, D.C., U.S. Department of Transportation, National Highway Traffic Safety Administration, special computer runs, unpublished, 1975.

**John Z. Delorean Corporation, "Automotive Occupant Protective Safety Expenditure/Benefit Study," for Allstate Insurance Co., August 1975.

***J. D. Flora, J. Bailey, and J. O'Day, "Financial Costs of Automobile Accidents," _HIT Lab Reports_, Vol. 5, No. 10, June 1975.

study of spinal cord injuries has indicated the incidence of specific types of impairment.[11] Estimates are also available of the total number of those with motor vehicle injuries who are receiving Federal disability payment. In addition, a study for the U.S. Air Force has indicated percentages of impairment for permanent total disability and for permanent partial disability based on experience of the Air Force with ground accidents.[12] A medical assessment was also made in conjunction with the development of the Comprehensive Injury Scale (CIS) of the potential percent of physical impairment for different severity levels of injury.[13] These and other sources were synthesized to develop estimates of disability.

Comprehensive injury scale assessment. In conjunction with development of the CIS, an assessment was made by a medical team of the extent of permanent impairment for specific injuries. A comparison of the

[11] J. F. Kraus, C. E. Franti, R. S. Riggins, D. Richards, and N. O. Burhani, *Incidence of Traumatic Spinal Cord Lesions*, Davis, Calif., University of California, School of Medicine, Departments of Community Health and Orthopedic Surgery, unpublished data, Oct. 1974.

[12] *Assessment of U.S. Air Force Injury and Fatality Cost Standards*, Norton AFB, Calif., Directorate of Aerospace Safety, July 1975.

[13] American Medical Association, unpublished correlation between AIS and CIS.

Table 10. Distribution and Average Income, AIS 3

Age	Percent of Total 20-64*	Percent of Age Group* in Dollars		Annual Average Income in Dollars**		Average, in Dollars, Male and Female
		Male	Female	Male	Female	
20-24	34.9	51.0	49.0	7,581	5,552	6,587
25-34	27.4	72.5	27.5	11,691	7,287	10,502
35-44	12.3	66.7	33.3	14,179	7,293	11,886
45-54	14.4	57.1	42.9	14,416	7,207	11,323
55-64	11.0	68.8	31.2	13,288	7,248	11,404
Weighted Average						9,523

*Restraint Systems Evaluation Program, Washington, D.C., U.S. Department of Transportation, National Highway Traffic Safety Administration, special computer runs, unpublished, 1975.

**_Money Income in 1973 of Families and Persons in the United States_, Washington, D.C., U.S. Department of Commerce, Bureau of the Census, Series P-60, No. 97, Jan. 1976.

Table 11. Average Work-Loss Days and Value of Loss, AIS 3

AIS 3 with:	Percent of AIS 3*	Average work-loss days**
Hospital stay:	72.1	
Short term only	68.8	7 + 29 = 36
Long term	3.3	7 + 64 + 281 = 352
No hospital stay with work loss	27.9	10 = 10
	100.0	39

Loss per day: $\frac{\$9,523}{260} = \$36.60$

Value of loss (1973) = 39 ($36.60) = $1427

Value of loss (1975) = 39 ($42.20) = $1645

*Restraint Systems Evaluation Program, Washington, D.C., U.S. Department of Transportation, National Highway Traffic Safety Administration, special computer runs, unpublished, 1975.

**Flora, J. D., Bailey, J., and O'Day, J., "Financial Costs of Automobile Accidents," in _HIT Lab Reports_, Vol. 5, No. 10, June 1975.

Table 12. Permanent Impairment Index (Percent of Impairment)

AIS	20 or Less	21-40	41-60	Weighted Average*
1	X			20 or less
2	X	X		20 or less
3	X	X		20 or less
4	X	X		21–40
5		X	X	21–40

*Based on Incidence Index in the American Medical Association Comprehensive Injury Scale.

Permanent Impairment Index[14] and the AIS yields the figures in table 12.

Applying this generalized scheme, the average impairment for AIS 4 and 5 would be 20 percent and 40 percent, respectively.

Development of Impairment Estimates for AIS 4 and 5. The data collected in the special study *Incidence of Traumatic Spinal Cord Lesion*[15] reveal the distribution of injuries and impairment shown in table 13.

These impairments were distributed over injuries at the AIS 3, 4, and 5 level as shown in table 14.

Table 15 presents the percent of total injuries in AIS accounted for by spinal cord injuries.

[14]The Permanent Impairment Index is a part of CIS.

[15]J. F. Kraus, C. E. Franti, R. S. Riggins, D. Richards, and N. O. Burhani, *Incidence of Traumatic Spinal Cord Lesions*, Davis, Calif., University of California, 1974.

Table 13. Total Motor Vehicle Spinal Cord Injuries

Injury Level	Percent	Number
Quadriplegia-paresis	28.7	1,795
Paraplegia-paresis	44.7	2,795
Other paralysis	22.4	1,400
No paralysis/ other impairment	4.2	260
Total	100.0	6,250

The following assumptions were made on extent of impairment:

Quadriplegia = 90%
Paraplegia = 50%
Other paralysis = 25%
No paralysis = No permanent impairment

Applying these percentages and the Overall Permanent Index from the CIS yields the impairment figures shown in table 16.

For the remaining portions of AIS 4 and 5, the CIS average impairment estimates were applied (see table 17).

The weighted averages are 24.7% impairment for AIS 4 and 56.7% impairment for AIS 5.

Alternative assessment of impairment. A study for the Air Force by the University of California at Los Angeles, entitled *Assessment of U.S. Air Force Injury and Fatality Cost Standards,*[16] estimated disability figures of 75% (maximum allowable) for permanent total disability and 66.8% (actual) for permanent partial

[16] *Assessment of U.S. Air Force Injury and Fatality Cost Standards*, Norton AFB, Calif., Directorate of Aerospace Safety, July 1975.

Table 14. Impairment Distribution by AIS

AIS	Quadriplegia and Paresis	Paraplegia and Paresis	Other Paralysis	No Paralysis	Total*
3	–	–	1,087	260	1,347
4	593	2,237	313	–	3,143
5	1,202	558	–	–	1,760
Total	1,795	2,795	1,400	260	6,250

*Distributed according to occurrence and incidence identified in the AMA CIS.

Table 15. Spinal Cord Injuries as Percent of Total Injuries in AIS

AIS	Total Spinal Cord	Quadriplegia	Paraplegia	Other Paralysis	No Paralysis
3	1.5	–	–	1.2	0.3
4	13.3	2.5	9.5	1.3	–
5	44.8	30.5	14.3	–	–

Table 16. Estimates of Impairment Combining Paralysis and CIS Assessments

Percent of AIS Injuries		Percent of Impairment
AIS 4	AIS 5	
2.5	30.5	90
9.5	14.3	50
1.3	–	25
13.3	44.8	

Table 17. CIS Average Impairment Estimates (AIS 4 and 5 Residual)

Percent of AIS Injuries		Percent of Impairment
AIS 4	AIS 5	
–	55.2	40
86.7	–	20
86.7	55.2	–

this study and on the U.S. Department of Transportation *Automobile Insurance and Compensation Study.*

Table 18. Distribution of Disability for Serious Injuries (Applied to AIS 3-5)

Disability	Percent of Serious Injuries
Permanent total	0.3
Permanent partial	6.5
No permanent	93.2

Based on the distribution and the assessment of disability, the following weighted average disability figures were developed:

- AIS 4: 18.5% = 66.8% remaining years;
  81.5% = 60 days average[18]
- AIS 5: 9.3% = 75.0% and
  90.7% = 66.8% remaining years;
  average = 60.0% disability remaining years.

Table 19. Stream of Future Income, AIS 4 and 5

Age	Average Future Income for Each Age in Age Group*
0-5	$150,135
6-14	152,855
15-19	195,850
20-24	226,115
25-44	200,620
45-64	140,050
Weighted average**	$193,120

*Figures are for 100% of future income; see adjustments for impairment.
**Weighted average, weighted from distribution by age in a sample from the Commission on Professional and Hospital Activities.

[17] "Economic Consequences of Automobile Accident Injuries," *Automobile Insurance and Compensation Study,* Vol. 1, Washington, D.C., U.S. Department of Transportation, 1970.

[18] Derived from excluding 18.5% permanent partial from Delorean estimate of total disability days including those with the probability of permanent disability.

losses, AIS 4 and 5. Based on the previous discussion and on calculated disability, the estimated production losses for AIS 4 and 5 appear in tables 19[19] and 20.

Table 20. Estimated Value of Future Production Loss, AIS 4 and 5

AIS 4*	
Percent of AIS 4 Injuries	Percent of Impairment
2.5	90
9.5	50
1.3	25
86.7	20
100.0	25**
AIS 4, Average value of production loss from disability:	
1973	$48,280
1975	$55,550
AIS 5	
Percent of AIS 5 Injuries	Percent of Impairment
30.5	90
14.3	50
55.2	40
100.0	57**
AIS 5, Average value of production loss from disability:	
1973	$110,080
1975	$126,650

*See disability discussion.
**Weighted average.

[19] *Money Income in 1973 of Families and Persons in the United States,* Washington, D.C., U.S. Department of Commerce, Bureau of the Census, Series P-60, No. 97, Jan. 1976; Restraint Systems Evaluation Program, Washington, D.C., U.S. Department of Transportation, National Highway Traffic Safety Administration, special computer runs, unpublished, 1975.

Home, Family, and Community Services Production Losses

The production losses outside the 40-hour workweek related to home, family, and community services are significant and are amenable to measurement on application of the opportunity cost principle. The opportunity cost concept is applied to these losses for the following reasons:

- To maintain consistency with the market and market-proxy production analysis
- To determine a proxy value that best reflects the value of production

Specifically, on the second point, there is no other reasonable alternative. To determine a value on the basis of replacement cost leaves one to determine whether or not the person would be replaced in a given function. Because many home or volunteer services might not be replaced, opportunity cost is a more direct measurement of the individual's production than replacement cost.

The average home, family, and community production losses for fatalities and injuries were determined on the basis of time devoted to the identified functions. The production time devoted to home and community was estimated, and the resulting percent of the 40-hour week was applied to the average dollar loss for market losses for each severity level. The lost production time was calculated and applied to the average dollar loss for proxy-market losses for each severity level. The average production was determined to be 10 hours per week for home and family sector production and 2 hours per week for volunteer activity. The combined total is 30% of the 40-hour week. This percent was applied to fatalities and injuries; the results appear in table 21.

The following two sections describe the derivation of these production losses.

Table 21. Home, Family, and Community Production Losses, 1975

AIS Level	No Discount Rate	7% Discount Rate in Dollars
6*	–	63,355
5	–	37,995
4	–	16,660
3	425	–
2	310	–
1	20	–

*Fatality.

Home and Family Sector Losses

These loss components include the following service production functions: home maintenance; household tasks; training, teaching, and counseling children; and many other functions. These productive services are lost if a fatality occurs and are diminished in proportion to disability and activity restrictions for injuries. The method of calculation is to estimate a percent of market production for these tasks and to apply the percentage to the previously determined opportunity-cost measurement of the workweek loss for fatalities and injuries.

As indicated in the introductory discussion of market and nonmarket production losses, the research on the value of home production has centered on the value of housewife production. The desired quantity for the present purposes is the value of production done outside the 8-hour workday by both men and women.

The following calculations were made in the derivation of an average value:

Estimates of the value of household production:[20]

	Percent of GNP
Morgan–Siragelding	38
Nordhaus–Tobin	48
Gauger	26
Average Value	36

Calculation of Household Production:

(a) 1973 Gross National Product (GNP) = $1,289.1 billion
(b) Average value household production 1973 = (0.36) ($1,289.1 billion) = $464.1 billion
(c) Total male income recipients 1973 20 years or older = 63.8 million[21]
(d) Average income, male income recipients 20 years or older = $10,215[22]
(e) Total income (c) × (d) = $651.78 billion

[20] Reuben Gronau, "The Measurement of Output of the Non-Market Sector: The Evaluation of Housewife's Time," *The Measurement of Economic and Social Performance*, New York: National Bureau of Economic Research, 1973.

[21] *Money Income in 1973 of Families and Persons in the United States*, Washington, D.C., U.S. Department of Commerce, Bureau of the Census, Series P-60, No. 97, January 1976.

[22] *Ibid.*

(f) Percent of household work contributed by male = 33%[23]
(g) Value of male household contribution (f) × (b) = 0.33 ($464.10 billion) = $153.15 billion
(h) Percent household production of total income (g)/(e) = $153.15/651.78 = 23.5%

The derived value of 23.5% is for males, but would apply to both men and women for non-8-hour-day home production losses. This figure does not include certain tasks relating to child raising such as teaching and counseling. Including these in the concept of total loss, the figure of 25% appears to be a reasonable approximation of value.

Volunteer Production

Volunteerism is an increasing phenomenon in U.S. production. The Center for a Volunteer Society has estimated that in 1974 the volunteer contribution to GNP was $50 billion. The National Center for Voluntary Action estimates that from 50 million to 60 million persons belong to volunteer groups.[24] (Five percent of the members are active at any one time.) Many kinds of community services are provided by these groups: rehabilitation work (ex-convicts, drug-users), help for the elderly and sick, advising children's groups (Scouts, Big Brothers), counseling, and religious activities. Corporations are encouraging volunteer action for their employees.

The component of volunteer production in this report is considered as that time spent outside the 40-hour workweek. Volunteer production for the 40-hour week has been measured in the opportunity cost measurement of market production.

The following calculations were made to derive the value of volunteer production:

(a) Contribution to GNP from volunteer production (1973) = $50 billion[25]
(b) Resident population, 20 years and older (1973) = 133.569 million[26]
(c) Average share per capita (a)/(b) = $374
(d) Average hourly earnings (1973) = $3.92[27]
(e) Average hours per year (c)/(d) = 95
(f) Average hours per week = 95/52 = 1.83
(g) Percent of weekly work hours = 1.83/40 = 4.6%

MEDICAL CARE COSTS

Overview

Billions of dollars are spent and large amounts of manpower resources are devoted to the Nation's personal health care. Of the total $96.8 billion spent on personal health care in 1974, $43.5 billion (45%) was for hospital costs, $20.7 billion (21%) was for physician costs, and $32.6 billion (34%) was for all other drugs and services.[28] An estimated $59.6 billion (62%) of the total $96.8 billion was paid by private sources and $37.2 billion (38%) was paid out of public funds.[29] For measurements of medical costs of motor vehicle fatalities and injuries, no attempt has been made to identify the source of payment. These total personal health care expenditure statistics are presented to give a general overview and point of comparison for the medical costs calculated for this study.

Medical treatment resulting from injuries and fatalities in motor vehicle accidents consumes medical resources that could be shifted in the long run to preventing and curing diseases. Medical costs are a measure of consumed medical resources. The following components of total medical costs can be identified: medical treatment at the scene, transportation and treatment enroute to medical facility, emergency room treatment, hospitalization, rehabilitation, long-term medical care at home or in extended-care facilities. Any or all of the above resources could be utilized, depending on the seriousness of the injury.

It should be pointed out that even though there is a strong correlation between the AIS and the medical resources devoted to the victim, a person may be seriously injured and may or may not have long-term medical side effects. Certain types of injuries will consume greater amounts of medical resources than others. Long-term medical ramifications are more difficult to determine than immediate effects from injuries, because many years may be required to determine the

[23] K. E. Walker and W. Gauger, "The Dollar Value of Household Work," Information Bulletin 60, *Consumer Economics and Public Policy*, No. 5, Ithaca, N.Y., 1973.

[24] "Helping People–An American Custom on the Rise," *U.S. News and World Report*, Sept. 2, 1974, pp. 29-32.

[25] *Ibid.*

[26] *Statistical Abstract of the U.S., 1975*, Washington, D.C., Department of Commerce, Bureau of the Census, July 1975.

[27] Ibid.

[28] M. S. Mueller and R. M. Gibson, "National Health Expenditures, Calendar Year 1974," *Research and Statistics Note*, No. 5, Washington, D.C., Social Security Administration, April 1976 (Preliminary figures).

[29] *Ibid.*

Non-Fatal Injuries

Incidence of Treatment

Since there is at present no ongoing data system that tracks motor vehicle injuries and their consequences, it is necessary to estimate medical costs from available sources. The Restraint System Evaluation Program (RSEP) has grouped data on 16,000 vehicle occupants in 1973-75 model vehicles according to various factors. Table 22[30] shows the treatment distribution derived from these data.

Table 22. Distribution of Occupants and Injuries by Type of Medical Treatment

Injury Level or Treatment Type	Percent of Total Occupants	Percent of Total Non-Fatal Injuries
Not injured	48.2	–
No treatment	10.3	20.2
First aid at scene	1.2	2.4
Consultation with doctor advised	3.0	5.4
Consultation with doctor	7.1	15.2
Emergency room treatment	20.4	43.1
Admission to hospital and release	4.3	9.0
Fatal	0.5	–
Unknown	4.9	4.7
Total	99.9	100.0

[30] Restraint Systems Evaluation Program, Washington, D.C., U.S. Department of Transportation, National Highway Traffic Safety Administration, special computer runs, unpublished, 1975.

Seen by physician (includes emergency room treatment)	58.3
Required hospital stay	9.0
Unknown	4.7

The data above and in table 22 are complete in terms of identifying the medical treatment of injuries. The major problem in the data is that their coverage is only of late model vehicles in tow-away accidents. By contrast, data from the Department of Health, Education, and Welfare (HEW)[31] on all moving vehicle injuries are given in table 23.

Table 23. Moving Motor Vehicle Injuries Data

HEW	Number in Thousands	Percent
Total injuries, 1973	3,927	100.0
Injuries seen by physician	3,467	88.3
Injuries requiring hospital stay	561	14.3

Table 24 shows the distribution by AIS and treatment from the RSEP file.[32]

Treatment distributions are valid within the given AIS level. This type of information is needed to isolate costs by incidence of treatment. From the data in table 22 the cost factors in table 25 were identified.

Emergency Care Costs

Table 24 indicates the percentage of each AIS level with emergency care costs. Injuries in each group with such costs include those who were transported, those who were treated in the emergency room and released, and those who were admitted to the hospital. A data

[31] National Health Survey, 1973, Rockville, Md., U.S. Department of Health, Education, and Welfare, National Center for Health Statistics, unpublished data, 1975.

[32] Restraint Systems Evaluation Program, Washington, D.C., U.S. Department of Transportation, National Highway Traffic Safety Administration, special computer runs, unpublished, 1975.

Received no treatment	26.8	1.7	0.6	–	–
Received first aid at scene	3.1	0.2	–	–	–
Directed to consult doctor	7.1	0.6	–	–	–
Consulted doctor only	19.0	7.1	3.6	–	–
Received emergency room treatment and released	40.7	62.5	23.7	–	–
Admitted to hospital	3.2	27.9	72.1	100.0	100.0
Total	100.0	100.0	100.0	100.0	100.0

*File data adjusted for unknown.
**File data adjusted for miscoding.

Table 25. Cost Factors, Percent of RSEP Non-Fatal Injuries

Treatment Type	Cost Type			
	Ambulance	Physician Care	ER Care	Hospital Care
Consulted doctor	–	15.2	–	–
Received emergency room treatment and released	43.1	43.1	43.1	–
Admitted to hospital	9.0	9.0	9.0	9.0
Percent of total injured with applicable cost	52.1	67.3	52.1	9.0

survey done in conjunction with *The Statewide Highway Safety Program Assessment*[33] indicated an average emergency transportation cost of $30 in 1973. Data on emergency hospital care are not collected on an ongoing basis. A special study of Blue Cross records done in conjunction with the RSEP has tabulated outpatient and inpatient costs by specific hospital codes.[34] These sources were used to derive average emergency transportation and care costs, as shown in table 26.

[33] *The Statewide Highway Safety Program Assessment, A National Estimate of Performance*, Washington, D.C., U.S. Department of Transportation, National Highway Traffic Safety Administration, July 1975.

[34] Survey of Blue Cross Insurance Company, unpublished data, 1975.

Table 26. Emergency Care Cost by AIS Level

AIS	Cost in Dollars for Those Receiving:				Percent Receiving Transportation and ER Care***	Average Cost in Dollars per AIS Injury 1975	
	Transportation*		ER Care**			Transportation	ER Care
	1973	1975	1973	1975			
1	30	38	40	50	43.9	15	20
2	30	38	50	60	90.4	35	55
3	30	38	60	75	95.8	35	70
4	30	38	115	145	100.0	40	145
5	30	38	150	190	100.0	40	190

*_The Statewide Highway Safety Program Assessment, A National Estimate of Performance_, Washington, D.C., U.S. Department of Transportation, National Highway Traffic Safety Administration, July 1975.
**Blue Cross Insurance Company.
***Restraint Systems Evaluation Program, Washington, D.C., U.S. Department of Transportation, National Highway Traffic Safety Administration, special computer runs, unpublished, 1975.

hospitals (defined as less than thirty days' stay). A special study was conducted using the CPHA 7th Patient Sample (United States only) to identify average stays and other characteristics of patients.[35] The sample of 23,000 patients used for the present study were those patients identified by a motor vehicle code within the Professional Activity Study (PAS) 7th Patient Sample. The data are for calendar year 1973. The basic distribution derived appears in tables 27 and 28.

Table 27. Distribution of Professional Activity Study (PAS) Sample Patients

Patient Classification	Number	Percent of Total	Average Stay (Days)
Total patients	23,168	100.0	10.0
Discharged alive	21,704	93.7	9.6
Transferred	963	4.2	19.5
Died	501	2.2	9.1

[35] Commission on Professional and Hospital Activities.

sity for a special study in 1975.

The cost data on average daily charges for 1973 were obtained from published HEW data. The average charge per day in 1973 was $109.[37] The first two days of a hospital stay are the costliest, since it is on these days that intensive treatment, tests, operations, and x-rays occur. In subsequent days, maintenance costs become a larger share of total cost. Average short-term hospital costs were estimated as shown in table 29.

Long-Term Hospital Costs

In addition to short-term hospital costs, to which the data from the CPHA sample relate, certain very serious injuries result in longer-term hospitalization or care. The percentages for those patients transferred were examined

[36] Additional data on total patients and average stay were obtained from the special study on AIS classification based on patient age and vehicle source of injury and on age, sex, and vehicle source of injury, via the PAS sample, but are not presented in this study.

[37] Health Insurance Institute.

Table 28. Percent Distribution, Average Hospital Stay, and Discharge Status by AIS Level

Patient Classification	Percent of Total	Average Stay (Days)	Percent Discharged Alive	Percent Transferred
Total, discharged alive, and transferred	100.0	10.0	95.8	4.2
AIS 1	14.4	5.7	98.2	1.8
AIS 2	41.5	10.4	96.2	3.8
AIS 3	38.6	10.4	95.5	4.5
AIS 4	3.1	14.0	92.8	7.2
AIS 5	2.4	21.6	81.7	18.3

Table 29. Average Short-Term Hospital Costs, Non-Fatal Injuries

AIS	Average Cost in Dollars for Injuries Hospitalized	Percent Hospitalized	Average Cost in Dollars per AIS Injury	
			1973	1975*
1	620	3.2	20	25
2	1,135	27.9	317	395
3	1,135	72.1	820	1,025
4	1,525	100.0	1,525	1,910
5	2,355	100.0	2,355	2,950

*See appendix C.

Table 30. Percent of Injuries Resulting in Long-Term Care or Transfer

AIS	Percent Hospitalized*	Percent Transferred**	Percent of Total Injuries Transferred
1	3.2	1.8	0.1
2	27.9	3.8	1.1
3	72.1	4.5	3.2
4	100.0	7.2	7.2
5	100.0	18.3	18.3

*See table 24.
**See table 28.

Table 31. Long-Term Care Costs, AIS 4 and 5

Item	AIS 4	AIS 5
Long-term hospital:		
Average stay* (days)	46	68
Average cost per day*	$ 47	$ 47
Percent transferred	7.2	18.3
Cost, 1973	$155	$585
Cost, 1975	$195	$730
Nursing home:		
Average monthly/yearly charge		
1973**	–	$510/$6,120
1975	–	$640/$7,680
Average stay (years)	–	2.63
Percent injuries	–	9.3
Average cost per injury	–	$1,880

*American Hospital Association.
**National Nursing Home Survey, 1973-1974, Rockville, Md., U.S. Department of Health, Education, and Welfare, Division of Health Resource Utilization Statistics, National Center for Health Statistics, unpublished tables.

Physician Costs

As with hospital costs the average cost per injury in a given severity level depends on the incidence of treatment. The figures in table 32 relate to the incidence of physician costs.[38]

Unit costs for physicians are shown in table 33.

Average costs combining these two data sets appear in table 34.

Rehabilitation Costs

The resources associated with rehabilitating serious motor vehicle injuries could be shifted in the long run to respond to physical problems from disease or to general health care. Rehabilitation costs were estimated only for AIS 4 and 5, as shown in table 35.[39]

[38] See table 24.

[39] Based on estimates from the Rehabilitation Institute of Chicago.

Table 32. Cost Incidence for Physician Costs, Percent of Total Injuries by Severity

AIS	Physician in Hospital	Physician Outside Hospital (Only)	Total
1	3.2	59.7	62.9
2	27.9	69.6	97.5
3	72.1	27.3	99.4
4	100.0	–	100.0
5	100.0	–	100.0

Table 33. Physician Cost, In and Outside Hospital (Dollars)

AIS	Physician in Hospital		Physician Outside Hospital	
	1973	1975	1973	1975
1	100	125	50	60
2	200	245	75	90
3	500	610	150	185
Total physician, 1975:				
4		2,120		
5		5,480		

Table 34. Average Physician Costs, Non-Fatal Injuries, 1975* (Dollars)

AIS	Average Cost
1	40
2	130
3	490
4	2,160
5	5,520

*See tables 32 and 33.

Table 35. Estimated Rehabilitation Costs, AIS 4 and 5

AIS	1973	1975
4	$2,550	$3,040
5	$5,100	$6,075

Summary of Medical Costs, Nonfatal Injuries

Table 36 displays medical costs for each AIS level nonfatal injury.

Fatalities

The medical resources devoted to accident casualties who die are related to the time and place of the fatality occurrence. Emergency transportation costs apply to all fatalities, whether they are taken to a hospital and/or to a mortuary. Emergency room and hospital care costs apply only to a portion of fatalities. Table 37 presents the distribution of place of death for fatalities in 1973.[40]

[40] Fatal Accident Report System (FARS), Washington, D.C., U.S. Department of Transportation, National Highway Traffic Safety Administration, unpublished computer runs, 1976.

Table 36. Cumulative Medical Costs, Non-Fatal Injuries, 1975 (Dollars)

AIS	Hospital	Physician	Rehabilitation	Other
1	45	40	–	15
2	450	130	–	35
3	1,095	490	–	35
4	2,250	2,120	3,040	40
5	5,750	5,480	6,075	40

Table 37. Fatalities by Place of Death (Percent)

Place of Death	Vehicle Occupants	All Others	Total in File
At scene	56.2	43.8	53.1
En route	5.7	6.4	5.8
Before admission (ER)	33.2	41.2	35.2
After admission	5.0	8.6	5.9
Total	100.0	100.0	100.0

Unit costs for care are as follows:

Emergency transportation	$30 per run[41]
Emergency room treatment	$150[42]
Hospital care	$990[43]
Physician care	$315[44]

Combining these percentages and costs yields the following average costs:

Emergency Transportation:
30% = 1 run
70% = 2 runs
(to hospital, to mortuary)
0.30 ($30) + 0.70 ($60) = $50

Emergency Room Treatment:
23.1 + 5.8 + 35.2 + 5.9 = 70%
0.70 ($150) = $105

Hospital and Physician Care:
Hospital 0.059 ($990) = $ 60
Physician 0.411 ($315) = $130
(Includes those dying in emergency room (35.2%) and after admission (5.9%))

The totals are:
Hospital $60 + $105 = $165 (hospital + emergency room)
Physician and other (emergency transportation) $130 + $50 = $180
Total = $345

Coroner-Medical Examiner

Coroner-Medical Examiner costs from a study on the indirect costs of accidents[45] were $85 in 1969. Price adjustments of 1973 and 1975 yield an average cost of $110 and $130 per fatality, respectively. This cost applies to 100% of fatalities.

FUNERAL COSTS

The measurement of funeral costs is the difference between the present value of average funeral costs that would occur in a future year and the average funeral cost in the current year. Even though funeral costs are experienced ultimately, future money is worth less than present money, and funeral costs experienced in the current year are relatively higher for that reason. The following identifies the calculated funeral costs:

Average funeral cost 1973 = $990 (range $500-$1800)[46]
Consumer Price Index (CPT) update 1973-75 = 13.5%[47]
Average funeral cost 1975 = $1,125

[41] *The Statewide Highway Safety Program Assessment, A National Estimate of Performance*, Washington, D.C., U.S. Department of Transportation, National Highway Traffic Safety Administration, July 1975.

[42] Restraint Systems Evaluation Program, Washington, D.C., U.S. Department of Transportation, National Highway Traffic Safety Administration, special computer runs, unpublished, 1975.

[43] Commission on Professional and Hospital Activities.

[44] Derived from information in John Z. Delorean Corporation, "Automotive Occupant Protective Safety Expenditure/Benefit Study," for Allstate Insurance Co., August 1975.

[45] H. Wuerdemann and H. Joksch, *National Indirect Costs of Motor Vehicle Accidents*, Center for the Environment and Man, Report 4114-494-B, June 1973.

[46] *Federal Trade Commission Survey of Funeral Prices in the District of Columbia*, Washington, D.C., Federal Trade Commission, Bureau of Consumer Protection, Division of Special Projects, 1974.

[47] "Consumer Price Index–U.S. Average," table 25, *Monthly Labor Review*, Washington, D.C., U.S. Department of Labor, Bureau of Labor Statistics.

	Female	45.5
Percent distribution of fatalities:[50]	Male	73.5
	Female	26.5

Weighted average remaining years 44.5 (0.735) + 45.5 (0.265) = 45

Productivity price increase 3% per year = $1,125 (3.7816) = $4,255

Discounted (7% present worth factor) = $4,255 (0.0376) = $200

Net difference 1975, future cost = $1,125 – 200 = $925

LOSSES TO OTHERS

Costs associated with losses to others include employer losses (temporary or permanent replacement costs), time spent visiting patients, transportation for medical attention, home care, and time spent in vehicle repair and replacement. The basic concept for loss measurement is the opportunity cost of time spent by others in these activities.

Estimates of losses (table 38) to others in the 1972 Societal Cost study[51] were used to derive the present estimates according to the following method:

AIS 1, 50% of market production loss

AIS 2, 1971 cost updated to 1973 for nonpermanent disability injury

AIS 3, AIS 2 proportion–losses to others to market production loss

AIS 4 and 5, 1971 proportion of market production loss, for permanent partial impairment injuries

Fatality, 1971 fatality proportion of market production loss

AIS 2	115	130
AIS 3	225	260
AIS 4	1,595	1,830
AIS 5	3,630	4,180
Fatality	3,200	3,685

LEGAL AND COURT COSTS

The concept of loss applicable to legal and court costs is that of resource consumption in response to accident consequences; the resources consumed are legal and judicial. There are two elements of cost; tort actions and accident citation costs. Within each of these are private (legal) and public (legal and court) costs. Since the limited amount of data on these costs has never been collected on the basis of the AIS injury classification system, it was necessary to estimate AIS legal and court costs. As with certain other categories of loss, legal and court costs are not applicable to all fatalities and injuries. In per-applicable-case terms, these costs are higher than when averaged over all fatalities or injuries in a given injury level.

Tort Action Costs

Legal and court costs associated with legal actions for damages are not experienced in all cases of fatality or nonfatal injury. Therefore, the incidence of these costs must be considered as well as the unit costs involved. The following text and tables 39 through 45[52] indicate the calculation of legal and court costs of tort actions.

Court Costs:

Cost per case tried 1968 (average of Federal, State and Local) = $4,675[53]

Government wage index 1968-75 = 57.7%[54]

1975 Cost = $7,370

[48] "Motor Vehicle Deaths, 1973," *Vital Statistics of the U.S., 1973*, Rockville, Md., U.S. Department of Health, Education, and Welfare, National Center for Health Statistics, 1975.

[49] Social Security Administration, Office of the Actuary, unpublished computer runs on life expectancy.

[50] Fatal Accident Report System (FARS), Washington, D.C., U.S. Department of Transportation, National Highway Traffic Safety Administration, unpublished computer runs, 1976.

[51] *Societal Costs of Motor Vehicle Accidents: Preliminary Report*, Washington, D.C., National Highway Safety Administration, April 1972.

[52] "Economic Consequences of Automobile Accident Injuries," in *Automobile Insurance and Compensation Study*, Washington, D.C., U.S. Department of Transportation, 1970.

[53] "Automobile Accident Litigation," *Automobile Insurance and Compensation Study*, Washington, D.C., U.S. Department of Transportation, 1968.

[54] *Statistical Abstract of the U.S.*, Washington, D.C., U.S. Department of Commerce, Bureau of the Census.

Table 39. Percent of Total Injuries in Severity Class by Legal Action*

Injury Level	Retained Counsel	Filed/Terminated Lawsuits	
		Total	Suits Tried in Court
Fatality	26.5	19.5	2.5
AIS 5	26.5	19.5	2.5
AIS 4	26.5	19.5	2.5
AIS 3	19.2	14.1	1.8
AIS 2	4.8	3.4	0.4
AIS 1	4.8	3.4	0.4

*Adjusted from percentages of one-vehicle accidents.

Table 40. Average Tort Court Cost by Injury Severity

Category	Applicable Percentage	Court Costs in Dollars, 1975	Average Cost per Injury in Dollars
Fatality	2.5	7,370	185
AIS 5	2.5	–	185
AIS 4	2.5	–	185
AIS 3	1.8	–	135
AIS 2	0.4	–	30
AIS 1	0.4	–	30

Table 41. Percent Injured Retaining Counsel by Action Taken*

	No Suit Filed	Suit Filed and Terminated	Total
Fatality	7.0	19.5	26.5
AIS 5	7.0	19.5	26.5
AIS 4	7.0	19.5	26.5
AIS 3	5.1	14.1	19.2
AIS 2	1.4	3.4	4.8
AIS 1	1.4	3.4	4.8

*See table 39.

Table 42. Plaintiff Costs as Percent of Estimated Recovery

Injury Level	Estimate Recovery in Dollars*	Percent Legal of Recovery*	Plaintiff Cost Per Suit Filed in Dollars
Fatality	30.940	26	8,045
AIS 5	20,225	26	5,260
AIS 4	9,240	26	2,400
AIS 3	7,445	32	2,380
AIS 2	4,275	25	1,080
AIS 1	2,800	27	750

*Percentage of loss from "Economic Consequences of Automobile Accident Injuries," in *Automobile Insurance and Compensation Study*, Washington, D.C.: U.S. Department of Transportation, 1970, applies to estimate of tort-coverable loss from present study.

AIS 4	0.070 ($430) = $30	0.195 ($2,400) = $470	500
AIS 3	0.051 ($430) = $20	0.141 ($2,380) = $335	355
AIS 2	0.014 ($430) = $6	0.034 ($1,080) = $35	40
AIS 1	0.014 ($430) = $6	0.034 ($750) = $25	30

Table 44. Defendant Legal Costs

Injury Level	Suit Filed and Terminated	Total in Dollars
Fatality	0.195 ($1,830)	355
AIS 5	0.195 ($1,830)	355
AIS 4	0.195 ($1,830)	355
AIS 3	0.141 ($1,830)	260
AIS 2	0.034 ($1,830)	60
AIS 1	0.034 ($1,830)	60

Table 45. Average Tort Action Legal and Court Costs, 1975, Summary (Dollars)

Category	Court	Legal	Total
Fatality	185	1,955	2,140
AIS 5	185	1,410	1,595
AIS 4	185	855	1,040
AIS 3	135	615	750
AIS 2	30	100	130
AIS 1	30	90	120

Defendant Cost:

1968, $820 per case plus $250 expenses[55]
Consumer price increase in legal services 1968-75 = 71%
1975 Cost = $1,400 + $430 = $1,830[56]

Accident Citation Costs

The second component of legal and court costs are the costs associated with traffic citations issued in accidents. Administrative adjudication of traffic offenses will undoubtedly reduce these costs in the future. The recently completed phase of the *Statewide Highway Safety Program Assessment*[57] estimated the following data for 1973:

Total citations, 36.1 million
Serious citations, 9.0 million
Accident citations, 4.9 million

A comparison of this total with the total number of accidents in 1973[58] reveals that 29.5% of the total of accidents involved citations.

Accident citation costs are composed of court and prosecution costs.

[55] "Automobile Accident Litigation," *Automobile Insurance and Compensation Study*, Washington, D.C., U.S. Department of Transportation, 1968.

[56] "Consumer Price Index," *Monthly Labor Review*, Washington, D.C., U.S. Department of Labor, Bureau of Labor Statistics.

[57] *The Statewide Highway Safety Program Assessment, A National Estimate of Performance*, Washington, D.C., U.S. Department of Transportation, National Highway Traffic Safety Administration, July 1975.

[58] *Accident Facts, 1974*, Chicago, National Safety Council.

Average cost per case (high estimate), 1969[59]	= $100
Average cost, 1973[60]	= $125
Percent of accidents with citations[61]	= 24.8%
Average cost per accident	= $30 (1973)
Average cost per accident	= $35 (1975)
Average cost per fatality AIS 4 and 5[62]	= $35 (0.862) = $30

Court costs, AIS 4, 5, and 6:

Average cost, 1973	= $85
Percent of accidents with citation	= 24.8%
Average cost per accident	= $20 (1973)
	= $25 (1975)
Average cost per fatality, AIS 4 and 5 injury	= $25 (0.862) = $20

Prosecution costs, AIS 1, 2, and 3:

Percent of accidents with accident citations[63]	= 26.8%
Average cost per case[64]	= $45 (1969)
	= $55 (1973)
Average cost per accident (0.268) ($55)	= $15 (1973)
	= $17 (1975)

[59] H. Wuerdemann and H. Joksch, *National Indirect Costs of Motor Vehicle Accidents*, Hartford, Conn., Center for the Environment and Man, Report 4114-494-B, June 1973.

[60] Updated using State and Local Wage Index, Census, *Statistical Abstract.*

[61] Estimated for each level injury using *The Statewide Highway Safety Program Assessment, A National Estimate of Performance*, Washington, D.C., U.S. Department of Transportation, National Highway Traffic Safety Administration, July 1975; *Accident Facts*, 1974, Chicago, National Safety Council.

[62] Per injury adjustment from cost per accident.

[63] *The Statewide Highway Safety Program Assessment, A National Estimate of Performance*, Washington, D.C., U.S. Department of Transportation, National Highway Traffic Safety Administration, July 1975; *Accident Facts*, 1974, Chicago, National Safety Council.

[64] H. Wuerdemann and H. Joksch, *National Indirect Costs of Motor Vehicle Accidents*, Hartford, Conn., Center for the Environment and Man, Report 4114-494-B, June 1973.

Percent of accidents with accident citations	= 26.8%
Average cost per case[65]	= $30 (1969)
	= $40 (1973)
Average cost per accident (0.268) ($40)	= $10 (1973)
	= $11 (1975)
Average cost per injury (0.65) ($11)	= $ 7 (1975)

Prosecution costs: property damage only (PDO) involvements

Percent of accidents with accident citations[66]	= 29.8%
Average cost per case[67]	= $15 (1969)
	= $20 (1973)
Average cost per accident (0.298) ($20)	= $ 6 (1973)
	= $ 7 (1975)
Average cost per vehicle (0.593) ($7)	= $4 (1975)

Court costs: PDO involvements

Percent of accidents with accident citations	= 29.8%
Average cost per case[68]	= $10 (1969)
	= $12 (1973)
Average cost per accident (0.298) ($12)	= $ 4 (1973)
	= $ 5 (1975)
Average cost per vehicle (0.593) ($5)	= $ 3 (1975)

Summary, Legal and Court Costs

Table 46 summarizes legal and court costs resulting from accidents.

[65] *Ibid.*

[66] *The Statewide Highway Safety Program Assessment, A National Estimate of Performance*, Washington, D.C., U.S. Department of Transportation, National Highway Traffic Safety Administration, July 1975; *Accident Facts*, 1974, Chicago, National Safety Council.

[67] H. Wuerdemann and H. Joksch, *National Indirect Costs of Motor Vehicle Accidents*, Hartford, Conn., Center for the Environment and Man, Report 4114-494-B, June 1973.

[68] *Ibid.*

Category	Action	Citation	Total
Fatality	$2,140	$50	$2,190
AIS 5	1,595	50	1,645
AIS 4	1,040	50	1,090
AIS 3	750	20	770
AIS 2	130	20	150
AIS 1	120	20	140
PDO		7	7

Bodily injury liability	$300-340	$370-420
Property damage liability	40-42	50-52
Collision	40-50	50-60

*Consumer Price Index (CPI) Auto Insurance Premiums, see appendix C.

Table 48. Distribution of Accidents by Type of Collision, 1973

	Fatalities	Injuries	PDO Accidents
Pedestrian and two motor vehicles	62.2%	80.0%	81.3%
Other collision and noncollision	37.8	20.0	18.7

INSURANCE ADMINISTRATION COSTS

The costs of insurance overhead represent resources devoted to accidents that could be saved with the reduction of accidents. A study of indirect costs of motor vehicle accidents conducted by the Center for the Environment and Man (CEM)[69] was the basis for the cost estimates of severity. Table 47 indicates the average loss adjustment costs from this source.

Since these costs are not based on the severity basis being used in this report, the distribution was estimated in table 48.[70]

The distribution for fatal accidents was assumed to apply to fatalities and AIS 4 and 5 injuries. The costs for these two severities are therefore:

Fatalities and AIS 5 = 0.622 ($420) + 0.378 ($60) = $285

AIS 4 = 0.622 ($410) + 0.378 ($55) = $275

The distribution of costs for AIS 2 and 3 is as follows:

AIS 3 = $405 + $55 = $460/2 = $230

AIS 2 = $370 + $50 = $420/2 = $210

The AIS 1 cost is assumed to be equal to property damage involvement for the liability portion and to the low estimate of costs for collision.

(0.80) ($50) + 0.20 ($50) = $50

Insurance administration costs for PDO involvement will be less than cost per claim, since a portion of PDO accidents are not submitted to claim. (See table 49.)

0.813 ($50) + 0.187 ($50) = $50

0.60^{71} ($50) = $30 = average cost per PDO involvement

Table 49. Insurance Administration Costs, 1975 (Dollars)

Severity Level	Average Cost
PDO	30
AIS 1	50
AIS 2	220
AIS 3	240
AIS 4	285
AIS 5	295
AIS 6	295

[69] *Ibid.*

[70] *Accident Facts*, 1974, Chicago: National Safety Council.

[71] Based on Ford estimate that 39.5% of PDO involvement accidents do not repair damage.

variable according to the severity of the accident. The basic source for estimating accident investigation costs was the study by CEM on indirect costs of accidents.[72] The basic data and calculations are shown in tables 50 and 51.

Table 50. Basic Data, Accident Investigation Costs (Dollars)

Item	Fatality	Injury	Property Damage
Average cost per crash, 1969	65	30	7
Average cost per fatality, injury, and PDO involvement, 1969*	55	20	4
Average cost per fatality, injury, and PDO involvement, 1973**	70	30	5

*Adjusted according to *Accident Facts, 1970*, Chicago, National Safety Council.

**Factor adjustment: 1969-73 State and local wage index (Statistical Abstract of the U.S., 1975), 1973/1969 = 1.2835.

Table 51. Average Accident Investigation Costs by Severity in Dollars

Severity Level	1973	1975*
Fatality	70	80
AIS 5	70	80
AIS 4	60	70
AIS 3	40	45
AIS 2	30	35
AIS 1	25	28
PDO	5	6

*See appendix C.

[72] H. Wuerdemann and H. Joksch, *National Indirect Costs of Motor Vehicle Accidents*, Hartford, Conn., Center for the Environment and Man, Report 4114-494-B, June 1973.

cost and is subject to direct measurement. The cost of repairing vehicle damage amounts to a significant portion of total cost for low-severity accidents. The resources devoted to repairing vehicles can be shifted in the long run to increasing the existing levels of safety and maintenance of vehicles on the road, i.e., welfare-producing activities versus the present damage attenuation.

Efforts to collect vehicle crash damage data have increased in recent years in response to the rising cost of repair and, particularly, to the issuance of bumper standards for vehicle protection in low-speed impacts. Unfortunately, there is no data collection system that systematically collects data covering the entire spectrum of automobile collisions. There are many data collection systems in operation, most of which can provide information on a limited segment of accidents only.

At the present time, one of the most comprehensive accident-reporting systems for all levels of accidents for current model year vehicles is that operated by the Highway Loss Data Institute (HLDI) since 1972.[73] This system has collected data from seven of the largest auto insurance companies concerning policy coverage and accidents. The data are then combined into a comprehensive set of statistics broken down by make, series, and model year and provide accident frequency, average accident repair cost, and expected loss payment per vehicle-year. The sample is thought to be representative, in terms of size, geographical distribution, representation of driver, and vehicle type. The data contain claim frequency and distribution of claim cost (i.e., the cost to repair the car, minus the deductible amount) for individual cars, for classes of cars, and for all cars aggregated. The major shortcomings of the data are that the HLDI file contains collision claims only, and no identification of injury and severity.

Another source of vehicle repair data is the State Farm Insurance Company's *Current Model Year Study*.[74] This ongoing study contains a sample of repair cost estimates for both collision and property damage

[73] *Automobile Insurance Losses–Collision Coverages*, Washington, D.C., Insurance Institute for Highway Safety, Highway Loss Data Institute, annual.

[74] *Current Model Year Study*, Bloomington, Ill., State Farm Mutual Automobile Insurance Company, annually.

lower end. The main value of the data, then, is in establishing the baseline distribution of accidents by impact point and cost, and in supplying the only ongoing data on property damage claims; however, as with the HLDI files, there is no identification of injury severity. An additional and important source of specific accident cost data is the barrier crash tests performed on small cars and sedans by the Insurance Institute for Highway Safety.

All of these systems have some basic weaknesses in terms of specificity, primarily in not identifying cost by the injury severity scale being used in this study. A special computer run was done for the purposes of the current Societal Cost study by State Farm, based on their general claim file, not on the current model year file, which contains new cars only. The sample data covered all claim activity during November and December 1974 (current structure of the data files precluded a larger sampling period).[75] The sample indicated the following average claim costs: collision coverage, $474 (all claims) and $491 (all nonzero claims); property damage liability coverage, $350 (all claims) and $353 (all nonzero claims); and a weighted overall average of $415 (all claims) and $426 (all nonzero claims). An attempt was made to stratify these data by AIS categories without success, but the average costs per claim were informative generally.

Ultimately, the file used for the estimates in this study was a one-time study done by the General Electric Company for NHTSA under Title II of the Motor Vehicle Information and Cost Savings Act.[76] Data were

Cost Study.

TRAFFIC DELAY COSTS

For the present study of societal costs, a reevaluation of cost components was made to determine if any significant components had been omitted. The only potentially significant cost omitted was determined to be the costs to others in terms of the value of time if traffic delays were caused by accidents.

The problem of delays from traffic accidents has not been studied adequately, although there has been much work done on the value of time for various purposes.[77]

Table 52. Vehicle Repair Costs by Injury Severity (Dollars)

Severity Level	1973	1975*
(PDO)	604	748**
AIS 1	1,289	1,597
AIS 2	1,507	1,867
AIS 3	2,358	2,922
AIS 4	3,196	3,960
AIS 5	3,222***	3,992
AIS 6	3,222	3,992
Unknown	1,462	1,811
File Average	758	939

*See appendix C.
**Adjusted to figure in table 1 for unrepaired damage.
***Number of AIS 5 cases is not sufficient for valid estimate; therefore, fatality cost was assigned to this level.

Table 53. Accident Data—1973

Severity Level	(A) Total Accidents Adjusted	(B) Rush Hour, Mon.-Fri.		(C) Rush Hour, Mon.-Fri., Urban	
		%	No.	% of (B)	No.
Total	16,348,300	25.7	4,197,987	71.8	3,015,820
Fatal	48,300	18.4	8,887	34.9	3,100
Injury	1,950,000	25.7	501,150	66.9	335,270
PDO	14,350,000	25.7	3,687,950	72.6	2,677,450

[75] Special computer runs, State Farm Mutual Automobile Insurance Company, Bloomington, Ill., 1975.

[76] Development of Vehicle Rating for the Automobile Consumer Information Study, General Electric Company, DOT Contract No. DOT-HS-4-00903, unpublished, special computer run.

[77] T. Thomas and G. Thompson, *Value of Time by Trip Purpose*, Stanford, Calif., Stanford Research Institute, 1970.

related sources were used to estimate average traffic delay costs. Figures on vehicle hours of delay from the last-mentioned source are conservative ones for the following reasons: (1) The figures are for a minor accident in the a.m. rush hour; (2) response to the scene of the accident is shorter than normal because of in-place visual surveillance; and (3) the relationship of on-the-road to on-the-shoulder accident investigation is influenced by the fact that these were freeway accidents and, therefore, a greater effort was probably made to clear the road. However, the third reason is somewhat neutralized because traffic volumes (and, therefore, number of vehicles affected) are higher on freeways than on city streets.

Value of Time Data:

Table 54. Value of Time for Commuting

Income (in dollars)	% of Workers at Rush Hour*	Time Value per Hour** (in dollars)
4,000	10.6	0.277
4,000- 6,000	13.3	0.936
6,000- 7,500	14.0	1.154
7,500-10,000	21.3	2.120
10,000-15,000	27.1	2.943
15,000+	13.4	3.664
Weighted Average		2.055

Note.–Adjustment for increase in earnings 1969-73***
1973 value = 1.28 ($2.055) = $2.63

*"Home to Work Trips and Travel." *The Nationwide Personal Transportation Study*, Report No. 10, Washington, D.C., U.S. Department of Transportation, Federal Highway Administration, 1973.

**T. Thomas and G. Thompson, *Value of Time by Trip Purpose*, Stanford, Calif.: Stanford Research Institute, 1970.

****Statistical Abstract of the U.S.*, Washington, D.C.: U.S. Department of Commerce, Bureau of the Census.

[78] "Home to Work Trips and Travel," *The Nationwide Personal Transportation Study*, Report No. 10, Washington, D.C., U.S. Department of Transportation, Federal Highway Administration, 1973.

[79] M. A. Pittman and R. C. Loutzenheiser, *A Study of Accident Investigation Sites on the Gulf Freeway*, College Station, Texas, Texas Transportation Institute, 1972.

Time Loss Data:

Vehicle-hours lost per rush hour accident = 340[81]
Persons per vehicle, rush hour = 1.4[82]
Person hours lost per rush hour accident = 475

Cost data and method average costs (see above for base valued):

Fatality:	
Number of accidents	3,100
Person-hours lost per accident	475
Total hours lost	1,472,500
Cost per person-hour	$2.63
Total cost	$3,872,675
Number of total fatalities	56,040
Average cost per fatality, 1973	$70
1975 Update = $70 (1.1505)[83]	$80

AIS 4 and 5:	
Number of accidents	700
Total hours lost	332,500
Total cost	$874,475
Number total AIS 4 and 5 injuries	16,800[84]
Average cost per AIS 4 & 5 injury	$52
1975 Update	$60

AIS 1, 2 and 3:	
Number of accidents	333,926
Total hours lost	158,614,375
Total cost	$417,155,805
Number total AIS 1-3 injuries	2,983,200[85]

[80] *Accident Facts*, 1974, Chicago, National Safety Council.

[81] M. A. Pittman and R. C. Loutzenheiser, *A Study of Accident Investigation Sites on the Gulf Freeway*, College Station, Texas, Texas Transportation Institute, 1972.

[82] "Home to Work Trips and Travel," *The Nationwide Personal Transportation Study*, Report No. 10, Washington, D.C., U.S. Department of Transportation, Federal Highway Administration, 1973.

[83] See appendix C.

[84] Estimated from Restraint Systems Evaluation Program, Washington, D.C., U.S. Department of Transportation, National Highway Traffic Safety Administration, special computer runs, unpublished, 1975.

[85] *Ibid.*

Number of accidents	2,677,450
Total hours lost	1,271,788,750
Total cost	$3,344,804,410
Number total PDO involvements	24,194,100
Average cost per PDO involvement	$140
1975 Update	$160

PROPERTY-DAMAGE-ONLY INVOLVEMENT COSTS

The overwhelming majority of accidents occurring each year involve vehicle damage only with no resulting injuries. There were 16,350,000 accidents in 1973; of these, 14,350,000 (88%) were property damage only (PDO) accidents.[86] These involvements result in a low societal loss per case relative to injuries and fatalities, but the total cost of PDO involvements is significant.

The following loss components have been identified for PDO involvements:

- Vehicle damage
- Insurance administration (variable)
- Legal and court
- Police accident investigation
- Traffic delay

Discussion and derivation of these components can be found in previous sections of this report identified by these loss headings. Table 55 is a summary tabulation of costs per PDO involvement.

Table 55. Average Costs Per Property-Damage-Only Involvement (Dollars)

Component	1973	1975
Vehicle damage	255	315
Insurance administration	30	31
Legal and court	6	7
Police accident investigation	5	6
Traffic delay	140	160
Total	436	519

[86]This is an adjustment of the National Safety Council total based on excluding a portion for an additional number of nondisabling injury accidents not reported by NSC, *Accident Facts.*

suffering as a societal loss of motor vehicle accidents. Conceptually, pain and suffering are a loss in individual well-being suffered by the individual who is injured, and by the individual who is injured and who subsequently dies. Societal loss encompasses these individual losses. Therefore, it is logical to consider quantification of these losses. At this point, the concept of loss becomes difficult. The measurement of loss should be related to the magnitude of pain and suffering.

Part of the justification for measuring pain and suffering has come from the determination of the courts, acting in proxy for society, to allow pain and suffering to be a compensable loss. This determination can be used as a basis for measuring loss if the following conditions exist: (1) that a jury makes a determination as a proxy for society as a whole, (2) that an award for pain and suffering is based conceptually on the extent of the pain and suffering and is not a measure of guilt or culpability of the defendant, and (3) that a large enough sample of cases would be taken to eliminate any potential judicial bias.

Adoption of various kinds of no-fault insurance has brought the valuation of pain and suffering under increasing question. The various no-fault proposals deal with the problem of pain and suffering in different ways. Without undertaking a thorough review of no-fault, it must be recognized that some proposals exclude the possibilities of payment for pain and suffering but allow payment for permanent impairment, and at least one modified no-fault proposal (American Mutual Insurance Alliance)[87] suggests a provision for up to 50% of medical payment for pain and suffering for medical expenses up to $500 and 100% for medical expenses over $500.

A review of the literature in the field indicates that first-party coverage need not necessarily exclude losses for pain and suffering and that they can be determined either case by case or on a formula approach.

For the present study, a determined effort was made to evaluate current pain and suffering losses according to the three criteria stated. Unfortunately, the law is not statistically oriented for the most part. The valuation of pain and suffering in the 1972 *Societal Costs of Motor*

[87]M. G. Woodruff, J. R. Fonsesca, and A. M. Squillante, *Automobile Insurance and No-Fault Law*, Rochester, N.Y., Lawyers Cooperative Publishing Company, 1974.

date and in hindsight were probably not related specifically enough to motor vehicle injuries. No comparable compilation has been done for motor vehicle injuries. In terms of what the current court trends are, the following statement is more recent and more to the point than any other found in the current research:

> "Awarding damages for nonpecuniary injuries is not the most objective jury undertaking; there is considerable danger of jury speculation . . . The belief of modern juries that the burden of large judgments will be borne by insurance companies rather than individual defendants compounds the fear of inflated awards for nonpecuniary injuries. . . . The possible confusion of injuries resulting in duplicative awards is feared if too many categories of compensable injuries are created . . . Despite these difficulties, courts in the United States continue to recognize nonpecuniary injuries as compensable, pain and suffering being the most frequent example."[90]

cases to attempt to derive a value. The outcome of this investigation was that the valuation of pain and suffering did not satisfy the second criteria of measurement, i.e., that the awards made appear to be strongly related to a judgment of guilt. As a result of this finding and because of the problem of collecting a statistically valid sample by reading individual cases, it was determined that no dollar value could be estimated.

Other Non-Quantified Costs

There are a number of qualitative losses to both individuals and society that defy measurement, for example, losses in conjugal affection, grief to others, loss of personal relationships. These losses are real and should be part of any analysis of the effects of accident reduction in qualitative terms. However, no attempt was made to place a monetary value on these losses.

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[88] *Societal Costs of Motor Vehicle Accidents: Preliminary Report*, Washington, D.C., National Highway Traffic Safety Administration, April 1972.

[89] Melvin Belli, *Modern Trials*, Indianapolis, Ind., Bobbs Merrill Company, 1973.

[90] Jacob Stein, *Damages and Recovery*, Rochester, N.Y., Lawyers Cooperative Publishing Company, 1972.

The subject of appropriate discount rates for estimating future societal costs has been and continues to be controversial. For the present societal cost study, a 7% rate for discounting future production losses and for computing funeral costs was chosen. However, appendix B of this report indicates the future production losses and funeral costs for a 10% discount rate application together with summary cost figures. Application of a discount rate expresses the concept that present money is worth more than future money.

In the past, a rather broad range of discount rates was used in analyses of public programs. In an effort to achieve comparability among analyses of government agencies, the Office of Management and Budget (OMB) formulated a policy on discount rates. This policy, as outlined in the OMB circular A-94, March 1972, indicates use of a 10% discount rate for analyses of public programs, except where specifically exempted. However, the circular indicates that the discount rates prescribed are "suggested for use in the internal planning documents of the agencies in the Executive Branch," and "required for use in program analyses submitted to the Office of Management and Budget in support of legislative and budget programs" (underlining supplied). The approach taken by OMB was to derive a rate generally applicable to all programs. To this end, analyses were made of rates of investment return in various financial markets to determine "the average rate of return on private investment before taxes and after inflation" (underlining supplied). For purposes of resource allocation decisions relating to public funds from the top down, this is as good a rate as any. It is useful from the OMB perspective to have some consistency by which to compare expenditure of public funds.

However, in the determination of societal costs and especially for lost future production, the appropriate discount rate should relate to the incidence of loss. In the case of lost future production, it is individual casualties–family and individuals in society–who are affected. Here the question is what time-preference value is applicable to the individual. Therefore, even though the precise time preference for lost future production is difficult (income as proxy) to conceptualize, the average rate of return faced by individuals fits the present context better than an average rate of return in all markets (i.e., inclusive of rates available to businesses).

Table 56[91] indicates a derived weighted average rate of return for an individual.

[91] *Statistical Abstract of the U.S.*, Washington, D.C., U.S. Department of Commerce, Bureau of the Census.

Table 56. Derived Rate of Return for an Individual

Assets	Percent of Distribution of Assets Held by Households, 1973 (Weighting Factors)	Annual Rate of Return in Percent (Average 1970-74)
Time and savings bonds	23.3	5.0
U.S. Government bonds & other	3.9	6.0
State & municipal bonds	1.9	5.7
Corporate bonds	2.1	7.7
Corporate stock	27.8	5.5
Real estate	40.5*	10.0
Weighted Average		7.3

*Minus mortgages.

SUMMARY OF COSTS, 10% DISCOUNT RATE

Table 57 presents the average costs per fatality, per Abbreviated Injury Scale (AIS) level injury, and per vehicle for property damage only (PDO) accidents for a 10% discount rate.

Table 57. Societal Costs, Summary, 1975, 10% Discount Rate (Dollars)

Cost Component	Injury (AIS)						
	6 (Fatality)	5	4	3	2	1	PDO Only
Production/consumption market	145,670*	82,250*	36,075*	1,645	865	66	–
Home, family, and community	43,700*	24,675*	10,820*	425	310	20	–
Medical							
Hospital	275	5,750	2,250	1,095	450	45	–
Physician and others	160	5,520	2,160	525	165	55	–
Coroner-medical examiner	130	–	–	–	–	–	–
Rehabilitation	–	6,075	3,040	–	–	–	–
Funeral	1,080*	–	–	–	–	–	–
Legal and court	2,190	1,645	1,090	770	150	140	7
Insurance administration	295	295	285	240	220	52	30
Accident investigation	80	80	70	45	35	28	6
Losses to others	3,685	4,180	1,830	260	130	32	–
Vehicle damage	3,990	3,990	3,960	2,920	1,865	1,595	315
Traffic delay	80	60	60	160	160	160	160
Total	201,335	134,520	61,640	8,085	4,350	2,190	520

*10% discount rate.

APPENDIX C:
COST ADJUSTMENT FACTORS, 1973-75

To compensate for the time constraints on data reporting, all costs were computed for 1973 and updated to 1975. Section IV, Societal Cost Components, presented the 1975 figures for each component. Cost adjustment factors in table 58 were applied to the 1973 estimates.

Table 58. Cost Adjustment Factors, 1973-75

Societal Cost Component	Factor	% Increase 1973-75
Production losses Losses to others Traffic delay	Average hourly earnings—private sector*	15.05
Medical care	Consumer price index (CPI)**	
	Medical care	22.44
Hospital	Hospital care charges	25.28
Physician	Physician fees	22.58
Legal and court	CPI legal services**	19.12
Insurance administration	CPI, auto insurance premiums**	3.55
Accident investigation	State and local wage index*	13.96
Property damage	CPI, auto repair and maintenance**	23.90

**Statistical Abstract of the U.S.*, Washington, D.C., U.S. Department of Commerce, Bureau of the Census, 1975.
***Monthly Labor Review*, Washington, D.C., U.S. Department of Labor, Bureau of Labor Statistics.

PROBLEMS

The information sources available for an evaluation of societal costs of motor vehicle accidents are deficient in many respects. The basic problems in currently available data are lack of coverage and representation for all types of accidents and all levels of severity. In addition, an overriding problem in the area of cost evaluation is that there is no ongoing cost data system that reports basic fatality, injury, and property damage costs. Therefore, it is necessary to look to a number of scattered studies for evaluation of individual components. Furthermore, most of the studies that have produced cost data have not covered the entire spectrum of fatality, injury, and property-damage-only accidents.

Lastly, available cost data by the Abbreviated Injury Scale (AIS) classification of injuries are scarce. The scale has been increasingly accepted as a standard classification system, but its application has not as yet produced a large volume of data from representative samples of accidents. Therefore, presentation of costs on this basis requires stratification of many of the available component costs by the AIS levels.

Planned and Recommended Future Research

There are some encouraging developments in accident and injury reporting. The National Crash Severity Study will be operated by the National Highway Traffic Safety Administration (NHTSA) between 1976 and 1978 and will collect data on ICDA[92] hospital codes, the AIS, surgical treatment, hospital days, and days of restricted activity. There is some hope that additional cost-related factors can be included in this system. In addition, the National Accident Sampling System (NASS) is being developed currently by NHTSA and will be operational in 1980. The NASS is an extension and broadening of the multidisciplinary accident investigation concept. The objective is to produce nationally valid data through a probability sample of the Nation's accidents, based on data collected by investigation teams. Among the data elements to be included will be injury severity identification (OIC)[93], injury treatment and convalescence, and vehicle damage. Plans for this system are not complete, and it is hoped that additional cost-related data can be incorporated. In conjunction with the development of these two systems, a study is being planned by NHTSA to investigate the development of a number of injury-scaling systems that would indicate injury severity in terms of cost and other factors.

In addition to the work being done by the U.S. Department of Transportation, there are two ongoing injury data collection systems that should be expanded to produce injury cost data. One is the National Health Survey, a household interview survey conducted yearly by the National Center for Health Statistics. Because all types of health data are collected, it is unrealistic, both in terms of the operation of the system and its costs, to suggest expanding motor-vehicle-injury specific data collection as a permanent, annual part of the survey. However, a triannually expanded survey could produce useful data. Data on disability, restricted activity, injury severity, and hospital and physician resources could be part of an expanded motor injury section.

Another data collection system that has potential usefulness is the National Emergency Injury Surveillance System, operated by the Consumer Product Safety Commission. The system collects data from hospital emergency rooms daily on all types of injuries. Recently, a special arrangement was made by NHTSA to include motor vehicle injuries on a trial basis. The system would have to be expanded slightly to yield emergency treatment and hospital cost data. Its primary advantage is in producing current data on injuries.

It is hoped that a continuing interest in valid cost data will produce pressure for expanded data collection efforts. Current data availability is limited, and the estimates developed in this report should be interpreted with this in mind.

[92] International Classification of Diseases, Adapted.

[93] Occupant Injury Classification corresponds closely to AIS scale.

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ABSTRACT CITATIONS

NHTSA accession number ---------- HS-013 124

Title of document ---------- **MAXIMUM BRAKE PEDAL FORCES PRODUCED BY MALE AND FEMALE DRIVERS**

Abstract ---------- The object of this research was to obtain data concerning the maximum amount of brake pedal force that automobile drivers were able to sustain over a period of ten seconds. Subjects were told to apply the brakes in the test car as they would in a panic stop, and to exert as much force as possible on the pedal over the entire ten second test period. A total of 84 subjects were tested, including 42 males and 42 females. The results indicated that there is a wide distribution of values which characterizes the pedal force that the subjects were able to generate. Male subjects produced generally higher forces than did females. Over half the women tested were unable to exert more than 150 lbs. of force with either foot alone, but when both feet were applied to the pedal, force levels rose significantly.

Personal author(s) ---------- by C. R. VonBuseck
Corporate author (or author's affiliation) ---------- General Motors Corp.
Publication date; pagination ---------- 1973? ; 18p
Supplementary note ---------- Excerpts from Maximum Parking Brake Forces Applied by Male and Female Drivers (EM-23) BY R. L. Bierley, 1965, are included.
Availability ---------- Availability: Corporate author

NHTSA accession number ---------- HS-018 924

Title of document ---------- **NATURAL FREQUENCIES OF THE BIAS TIRE**

Abstract ---------- The lowest natural frequencies of a bias tire under inflation pressure are deduced by assuming the bias tire as a composite structure of a bias-laminated, toroidal membrane shell and rigorously taking three displacement components into consideration. The point collocation method is used to solve a derived system of differential equations with variable coefficients. It is found that the lowest natural frequencies calculated for two kinds of bias tire agree well with the corresponding experimental results in a wide range of inflation pressures. Results of the approximate analysis show that the influences of the in-plane inertia forces on natural frequency may be considered small, but the influences of in-plane displacements are large, particularly on the natural frequency of the tire under low inflation pressure.

Personal author(s) ---------- by Masami Hirano; Takashi Akasaka
Journal citation ---------- Publ: Tire Science and Technology v4 n2 p86-114 (May 1976)
Publication date ---------- 1976; 6refs
Availability ---------- Availability: See publication

fic accidents decreased from 62,754 in 1975 to 58,974 in 1976, a decrease of more than 6%. The consistent annual growth in motor vehicle registration continued in 1976. Motor vehicle fatalities decreased to 149, a 15% decrease from the 176 in 1975. The major decrease was in pedestrian fatalities, which decreased from 85 in 1975 to 65 in 1976, while occupant deaths decreased from 91 in 1975 to 84 in 1976. The 58,974 motor vehicle traffic accidents tabulated in the report were those reported and recorded by City Police. Data indicate that one out of every nine registered vehicles was involved in an accident in 1976. Total economic losses are in excess of $124 million. The most prevalent cause of vehicle accidents appears to be the driver who violated traffic regulations or safe driving practices. Accident rate per vehicle is lowest between 6 A.M. and 7 A.M., rises during the day, and peaks between 2 A.M. and 3 A.M. Physical hazards on or beside the roadway do not contribute significantly to accident incidence. Increased traffic safety education is judged most important in reducing accident rate. Traffic engineering and law enforcement also contribute to accident reduction.

Traffic Engineering Div., Dept. of Streets, Philadelphia, Pa.
1976; 39p
Cover title is "Traffic Accidents 1976 Philadelphia."
Availability: Corporate author

HS-021 331

VOICE OF THE PEDESTRIAN, 8. 1. REPORT OF THE WARSAW MEETING OF THE STANDING COMMITTEE ON TRAFFIC PROBLEMS OF THE INTERNATIONAL FEDERATION FOR HOUSING AND PLANNING. 2. OTHER PAPERS

Fourteen papers focus on the subject of pedestrian issues in international traffic planning problems. Traffic capacities of cities are deemed a function of number of available parking spaces. The city center traffic capacity concept can be used in traffic forecasting, particularly when it is inadvisable fully to meet demands for city center car traffic. City center capacity can be defined in terms of modal split and transportation policy, thus implying capacity for people and business activity. Urban transportation policy in Poland from 1945 to 1975 is reviewed. Current traffic planning procedures in Stockholm, Sweden are delineated. Parking policy, if engineered improperly, can be a threat to pedestrian safety due to traffic interference and restricted sight distance. On the other hand, if properly done it can deal effectively with traffic. A parking fund is used in Denmark to provide for free, well apportioned, and convenient parking in urban areas. Traffic problems specific to Hungarian city centers are remarked upon. Pedestrian injuries are investigated in relation to car exteriors which cause bodily injuries. Illustrated draft accessibility standards for disabled persons in the U.S. provide recommendations for special equipment and layout of public places. The new town of Stevenage, England is described in terms of its transportation, layout, highways, and car parks. The relation-

One paper is in German.
Availability: Corporate author

HS-021 332

VAPOURIZATION [VAPORIZATION] OF FUEL DROPS ON A HOT PLATE

Life times and behavior of fuel drops are studied by vaporizing fuel on a hot plate in open and closed atmospheres, and sequentially photographing the vaporizing mass. Four fuels were used: iso-octane, n-heptane, alpha-methyl naphthalene, and n-hexadecane. Ambient atmosphere (the ratio of air and nitrogen) was varied, as well as five different ambient atmospheric pressures. Plate temperature ranged from 50° to 350° C. Differences in vaporization characteristics are observed depending on parameter variations. Lifetime curves and motion pictures reveal different vaporization characteristics in air and nitrogen atmospheres. Vaporization behavior of much smaller satellite drops (300 microns diameter) which sometimes followed the large main drops seem to be different from that of the large drops. Volume of the film boiling drops can be determined reasonably using the correlation developed in terms of maximum diameter and height of the drop. Vaporization rate of the film boiling drop is found to be influenced by the drag effect on the drop bottom due to vapor flow. Volumes computed by the part sphere model are found to agree well with experimental values. The sphere model is adequate when vaporization takes place in open atmosphere. Film boiling drops become flattened at higher ambient pressures. The part sphere model predicts the size history of the drop for its entire lifetime in nitrogen atmosphere, even at higher pressures. However, the model needs refinements for use in air atmospheres. A nomenclature list is included.

by L. S. Murthy; R. Matarajan; K. K. Ramalingam
Indian Inst. of Tech., Dept. of Mechanical Engineering, India; Engineering College, Dept. of Mechanical Engineering, India
Rept. No. SAE-760762; 1976; 31p 15refs
Presented at Automobile Engineering Meeting, Dearborn, Mich., 18-22 Oct 1976.
Availability: SAE

HS-021 333

SIMULATION AND EVALUATION OF EXHAUST AND INTAKE SYSTEM OF A FOUR-STROKE SPARK IGNITION ENGINE

A mathematical model has been developed for the gas exchange process and to estimate the pressure, temperature, velocity, and mass flow rate at selected points in the exhaust and intake systems of a four stroke, single cylinder spark ignition engine. Evaluation of the model is accomplished by comparing computed data of gas pressure in intake system with experimental data. The model was also evaluated by comparing gas pressure and velocity. Computed data correlate satisfactorily with test data. Boundary condition expressions for the model are set up at valve and open ends of the

cylinder, based on direction of flow. Properties at selected points are estimated by the method of characteristics and path line calculations. The exhaust and intake system is divided into six meshes of equal length. Computed data were evaluated by conducting experiments on a single cylinder, horizontal four stroke, water-cooled spark ignition engine. Velocity, heat transfer, and mass flow were found to increase with respect to speed. When engine speed is raised the computed and test data of velocity increase appreciably. Magnitude of pulsations in the intake system increase with respect to crank angle, and the peak occurs a little before the reverse flow. Near the end of the intake process, since the mass flow decreases, the temperature starts increasing. The developed model can be used in the design of intake and exhaust systems. It can also be used in estimating the energy available in the exhaust gases, which will be useful in the design of turbochargers.

by M. K. Gajendra Babu; B. S. Murthy
University of Tokyo, Inst. of Space and Aeronautical Science, Japan; Indian Inst. of Tech., Dept. of Mechanical Engineering, India
Rept. No. SAE-760763; 1976; 14p 7refs
Presented at Automobile Engineering Meeting, Dearborn, Mich., 18-22 Oct 1976.
Availability: SAE

HS-021 334

PULSED PLASMA IGNITOR FOR INTERNAL COMBUSTION ENGINES

Preliminary test results are presented on a new type of ignition system which is designed to permit operation of an internal combustion engine in the ultralean region where there is a potential of reducing oxides of nitrogen (NOx) emissions and increasing engine efficiency. The new ignition system utilizes electromagnetic body forces to drive the ignition kernel into the combustion chamber acting, in effect, as an extended multiple source. The high current (about 1000 amperes) produced during the ignitor discharge induces a local magnetic field of sufficient magnitude to realize a JXB body force which accelerates the discharge plasma. The system is compatible with conventional ignition systems and does not require any basic engine modifications. A standard spark plug exhibits leaner performance when the discharge energy is comparable to the pulsed plasma ignitor. However, the pulsed plasma ignitor design appears to take greater advantage of the higher discharge energy. More work must be done to evaluate whether the improvement is due to the discharge plasma motion or the total volume occupied by the ignitor kernel. The lowest equivalence ratio (knee of the torque curve) is 0.51 for a pulsed plasma ignitor with an apparent improvement of about 2% in the absolute thermal efficiency (6% relative) over the standard ignition system used.

by Dennis J. Fitzgerald
California Inst. of Tech., Jet Propulsion Lab.
Rept. No. SAE-760764; 1976; 8p 6refs
Presented at Automobile Engineering Meeting, Dearborn, Mich., 18-22 Oct 1976.
Availability: SAE

HS-021 335

EVALUATION OF BURNED GAS RATIO (BGR) AS A PREDOMINANT FACTOR TO NOx [OXIDES OF NITROGEN]

Gas compositions in a cylinder at the end of the compression stroke are analyzed to elucidate the effects of exhaust gas recirculation (EGR). Experiments were conducted with four cylinder production engines. A gas sampling valve and carbon dioxide (C02) gas analyzer were used to measure BGR, which provides the basis for evaluating the effect of EGR and mixture stoichiometry on oxides of nitrogen (NOx). The burned gas fraction (BGR) is related to NOx emissions and misfire limit, which appear to be strongly affected by BGR at specified air fuel ratio (A/F) and spark timing. The ratio of total gas to fuel in the cylinder, termed gas-fuel ratio (G/F), is the predominant factor used extensively to evaluate effects of EGR and/or lean mixture on NOx and misfire limit of an engine. G/F ratio coupled with A/F could be utilized to evaluate the combustion characteristics such as NOx emission and misfire limit in various combustion chamber configurations. This factor was found to be almost unrelated to engine load conditions, engine speed and valve timing. NOx emission and misfire limit are strongly affected by the BGR in the cylinder. Stoichiometrically burned gas EGR has the best potential to reduce NOx together with power for a fixed engine displacement, but from the point of view of fuel economy and misfire limit indicated by G/F, its mixture is the second to leanest A/F, when the critical constraint of NOx and better fuel economy are considered. The combustion chamber design technique which is capable to wider lean misfire limit more than 24 of G/F should be developed in the future.

by Tadahide Toda; Hidetaka Nohira; Kiyoshi Kobashi
Toyota Motor Co., Ltd., Japan
Rept. No. SAE-760765; 1976; 16p 17refs
Presented at Automobile Engineering Meeting, Dearborn, Mich., 18-22 Oct 1976.
Availability: SAE

HS-021 336

EXHAUST PORT HEAT REJECTION IN A PISTON ENGINE. A PRELIMINARY REPORT

An experimental program has been developed which defines the magnitude of heat loss in exhaust ports and the effect of some geometric design variables and of several exhaust port liner designs on exhaust heat loss. Experiments were conducted on a 50 CID single cylinder engine built on a modified 400 CID V8 engine block. A port designed for minimum heat transfer may result in a 250° F increase in exhaust gas temperature. Results indicate a significant reduction in radiator requirements as well as greatly improved thermal reactor performance. A 26% reduction in heat transfer is obtained without a liner and an average 39% reduction is possible with an air gap when compared with a baseline 400 CID exhaust port configuration. This is significant in terms of increased exhaust gas temperature in the exhaust manifold/reactor, and also in terms of reduced load on the cooling system. Multicylinder heat transfer data, when compared with single-cylinder data from the present study indicate that a 20% reduction in cooling requirements is possible, which reduces cooling system cost. With this large a reduction in cooling system load, using port liners without the associated change in the cooling system could result in long warm-up time in a vehicle. The resultant hydrocarbon and carbon monoxide (HC and

CO) emissions may not be achieved with this system. On-going improvements in insulating properties involve incorporation of a liner into the freeflow design, liner coverage of the valve guide, push-in liners, insulating the contact areas of a cast-in liner, and improved insulating materials.

by James H. Rush
Ford Motor Co.
Rept. No. SAE-760766; 1976; 16p 6refs
Presented at Automobile Engineering Meeting, Dearborn, Mich., 18-22 Oct 1976.
Availability: SAE

HS-021 337

AN ANALYTICAL STUDY OF EXHAUST GAS HEAT LOSS IN A PISTON ENGINE EXHAUST PORT

A mathematical model of exhaust port heat loss has been evolved using an electrical analog of heat transfer. Exhaust port heat losses can be estimated from exhaust gas temperatures, flow rates, and consideration of port geometry. In a current production engine, the heat transfer to the exhaust port wall accounts for over 85% of the exhaust port heat loss. The remainder of the heat loss occurs through the exhaust valve. The effectiveness of a port liner is significantly limited by the liner/casting contact areas. With perfect insulation in the liner port studied, the liner/casting contact areas limited the reduction of port wall heat loss to 56%. For a port with relatively constant flow area and average diameter, the heat loss to the exhaust port wall is directly proportional to the wall surface area. Exhaust valve geometry appears to affect heat loss to the exhaust port wall. Appendices include a list of nomenclature and data on the gas side convection coefficient.

by S. D. Hires; G. L. Pochmara
Ford Motor Co.; Eaton Corp.
Rept. No. SAE-760767; 1976; 18p 14refs
Presented at Automobile Engineering Meeting, Dearborn, Mich., 18-22 Oct 1976.
Availability: SAE

HS-021 338

EFFECTS OF AUTOMOBILE STEERING CHARACTERISTICS ON DRIVER/VEHICLE PERFORMANCE FOR REGULATION TASKS

Driver and driver/vehicle system dynamic behaviors are examined in a regulation driving task wherein the driver maintains the car within a lane in the presence of random gustlike disturbances. Changes in vehicle dynamics, and insertion of the simulated gust, are accomplished using a variable stability automobile. The experiments show that drivers adjust their dynamics to keep some driver/vehicle system properties essentially constant. Regulation task measurements are interpreted as effective open-loop system describing functions. From these data, objective measures of system bandwidth, stability, effective time delay, and closed-loop damping are deduced and compared as functions of vehicle dynamics and driver gender. In adjusting to different vehicle dynamics, the typical drivers adopt equalization which is well accounted for by the crossover model of manual control theory. Driver lead equalization increases directly with, and compensates for, the vehicle effective time lag. System crossover frequency is about constant at 3.8 rad/sec for all the configurations. System phase margin and system stability increase and effective system latency decreases as yaw time constant and/or equivalent time constant are decreased. The phase margins, effective system latencies, and system stability depend on vehicle dynamics. Vehicles are clearly ordered in superiority in terms of these measures. Male drivers have slightly higher crossover frequencies than females. Female drivers exhibit slightly greater open-loop amplitude ratio slopes than males. Phase margins for male and female drivers are not significantly different.

by Duane McRuer; Richard Klein
Systems Technology, Inc.
Rept. No. SAE-760778; 1976; 18p 12refs
Presented at Automobile Engineering Meeting, Dearborn, Mich., 18-22 Oct 1976.
Availability: SAE
1976; 19p 21refs
Presented at Automobile Engineering Meeting, Dearborn, Mich., 18-22 Oct 1976.
Availability: SAE

HS-021 340

VEHICLE CONTROLLABILITY AND HUMAN RESPONSE CHARACTERISTICS

Controllability of a given vehicle can be predicted through use of a dynamic model of that vehicle and the response characteristics of a driver. The driver's response characteristics consist of his sensitivity to the degree of a vehicle's deviation from its course, its deviation velocity, and deviation acceleration. The simulation model has proven to be appropriate by comparing the simulation computation results with actual test results of lane changing, slaloming, and behavior against side wind. Though steady state turning circle, frequency response, and yaw damping characteristics differ quantitatively between computation and test, they tend to closely simulate the test results. When simulation models for the dynamic characteristics of a vehicle are available, they can be used on a "cut and try" basis in a computer to obtain driver response functions which create vehicle behavior closest to that encountered in driving. When computed in this manner, the behavior of a vehicle changing lanes, slaloming or in a side wind closely approximates that encountered in practical experience. Controllability of a vehicle under the influence of steady state turning circle, frequency response, and yaw damping characteristics cannot be estimated accurately without accounting for driver response functions. Behavior of a vehicle during braking can be discussed with a fixed steering wheel assumed. Appendices include symbols, development of basic motion equations, and experimentally obtained human response parameters.

by Keisuke Yoshimori
Nissan Motor Co., Ltd.
Rept. No. SAE-760780; 1976; 24p 2refs
Presented at Automobile Engineering Meeting, Dearborn, Mich., 18-22 Oct 1976.
Availability: SAE

HS-021 341

CATALYTIC CONVERTER TEMPERATURE TESTS

Tests conducted in 1975 to determine exhaust system temperatures on late-model vehicles indicate that, for normal operation, only small temperature differences exist at any point on a vehicle's exhaust system between those equipped with catalytic converters and those without catalytic converters. Direct forest fire hazard from catalytic converter-equipped vehicles is

essentially the same as with other exhaust systems, except when the vehicle engine malfunctions. The road and dynamometer test fleet consisted of 37 vehicles, which were not representative of the nationwide 1974-75 vehicle fleet. The hottest point on the exhaust system of nonconverter-equipped vehicles is likely to be the first bend. The hottest point on the exhaust system of converter-equipped vehicles is usually the outlet of the converter. A considerable portion of the exhaust systems of both converter-equipped and nonconverter-equipped vehicles, under severe operating conditions, are likely to be at temperatures in excess of that necessary to ignite ground-cover fuel in a relatively short contact time. Maximum exhaust system temperatures are obtained for all vehicles during high flow (wide-open throttle), high load operation. The coasting and cruise modes of operation do not lead to excessively high exhaust system temperatures even with one or more spark plugs misfiring on converter-equipped vehicles. Ignition system failures significantly increase exhaust system temperatures in converter-equipped vehicles. Exhaust gas from both vehicle types is cooled to a safe temperature by mixing with air within 1 inch of the exhaust system exit. A danger may exist for occupants of certain converter-equipped vehicles when the engine malfunctions. Any fuel lines near any part of the exhaust system downstream from the converter or any nonmetallic line segments should be repositioned or replaced.

by Robin T. Harrison
Department of Agriculture, Forest Service Equipment Devel. Center
Rept. No. SAE-760781; 1976; 14p 8refs
Presented at Automobile Engineering Meeting, Dearborn, Mich., 18-22 Oct 1976.
Availability: SAE

HS-021 342

TOYOTA'S INSPECTION SYSTEM FOR VEHICULAR EMISSIONS AT ASSEMBLY LINES

An emission performance assurance system called "end of line check and analysis system for exhaust emissions" (ECAS) has been developed and used on Toyota's assembly lines to ensure compliance of production vehicles with Japanese and U.S. emissions requirements. The system consists of four tests: idle, functional, short cycle, and steady state inspection tests. Automatic processing and computer control are used for system operations such as vehicle setup on a chassis dynamometer, statistical analysis of data, judgment of data obtained, type-out of results, indication for action to be taken, and statistical treatment and filing of data. In the short cycle test the up-stream emissions of the vehicle, tracing Toyota's short cyclic mode on a chassis dynamometer, are continuously measured. Based on emission levels during each mode and the total emission level, emission control systems can be diagnosed, in addition to engine conditions such as valve clearance maladjustment and carburetor defects. The emission measurement in the upstream gas, which is sampled at upstream gas plug, can evaluate engine conditions and assure prevention of catalyst failure due to overheating or other conditions. ECAS is not very effective in measuring performance in such conditions as cold engine, during warm-up, and high speed or high load driving.

by T. Tanaka; H. Nakano; I. Usami; N. Abe
Toyota Motor Co., Ltd., Japan
Rept. No. SAE-760782; 1976; 23p
Presented at Automobile Engineering Meeting, Dearborn, Mich., 18-22 Oct 1976.
Availability: SAE

HS-021 343

DEVELOPMENT OF CANISTERING SYSTEMS FOR MONOLITHIC CATALYSTS

Two canister systems have been developed which house monolithic catalysts and protect the catalysts from destruction throughout the life of a vehicle. The first version is an underhood system fitted directly to the exhaust manifold, which has to stand a very high exhaust gas temperature impact as well as gas pulsations and engine vibrations. The second version is a ceramic wrapping canister system developed for an underfloor catalyst configuration, which because of the lower thermal and mechanical loads can be designed in a more cost-efficient manner. For catalysts located close to the engine there could be peak pressures of up to 0.8 bar on the face of the catalyst carrier, depending on number of cylinders. Mechanical vibrations to which the catalyst is subjected are almost exclusively determined by vibration behavior of the engine. While in the case of the underhood catalyst the acceleration pattern is very similar to the engine vibrations, the accelerations of the underfloor catalyst are damped to a great extent by the exhaust system. Expenditure for a functionable holder could be less for an underfloor catalyst due to the lower loads. Exhaust gas temperatures and individual components of catalytic converters also affect service life of the catalyst holder. The high loads from exhaust gas pulsation and mechanical vibration have led to a holder for underhood catalysts, which utilizes radially and axially flexible damping and holding rings between the metal converter housing and the ceramic carrier. An effective underfloor catalyst holder has exclusively radial holding, accomplished by an insulating material on a mineral fiber basis, in which a micaceous component is embedded, which will swell heavily when subjected to heat.

by Jorg Abthoff; Kurt Oblander; E. Santiago; A. Santiago
Daimler-Benz AG, Germany; Zeuna-Starker, Germany
Rept. No. SAE-760783; 1976; 14p 4refs
Presented at Automobile Engineering Meeting, Dearborn, Mich., 18-22 Oct 1976.
Availability: SAE

HS-021 344

DESIGNING PARKING BRAKE SYSTEMS FOR LOWER EFFORTS

With the advent of Federal Motor Vehicle Safety Standard (FMVSS) 105-75, which imposed maximum effort to be applied to the parking brake on passenger vehicles to hold the vehicle on 20% and 30% grades, Ford Motor Co. instituted a program to achieve 40% average improvement in vehicle range in a cost effective manner. Performance objectives were set at a three-car average effort of 99 lbs for foot operated controls and 65 pounds for hand operated controls. To formulate the design and development program, a baseline was established, indicating current performance of each car line for the previous four years. Total system performance was broken down into nine items, each of which was evaluated for base line situation, expected possible improvements, development program timing, and cost effectiveness. Rear brake torque output has the most influence on system performance. Rear brake mechanical efficiency tests were conducted to quantify lever and strut deflection under load required to generate hill-holding torque. A study of four cable system configurations led to implementation of the Straight Through System. Cable assembly travel and load efficiencies remained virtually

unchanged due to cost considerations. Cable system slack adjustment is critical to system functioning, and can be regulated by securing controls to minimize operator error. Control assembly efficiency and component attachment rigidity were not improvable in a cost effective manner. Examination of allowable work input at the control, the last variable, indicated that pedal travel increase could be best achieved with a multistroke mechanism which provided 15 inches of travel. Customer benefits are difficult to evaluate at this time.

by Alan J. Cross
Sparton Manufacturing Co.
Rept. No. SAE-760785; 1976; 19p 2refs
Presented at Automobile Engineering Meeting, Dearborn, Mich., 18-22 Oct 1976.
Availability: SAE

HS-021 345

INTERACTIVE TRAILER TOWING SIMULATION

A vehicle-trailer handling model with interactive use is a high resolution simulation of general vehicle (passenger cars to multitrailer) handling, braking, and vehicle-barrier interaction which is exercised interactively with a "human driver" over a realistic road (pavement, shoulder, and median strip). At all times during the simulation, the operator can simulate the use of any normally available controls, i.e. steering braking, throttle. The human being in the loop makes dynamic decisions using a computer assisted "play" of the scenario. The computer is programmed to determine the consequences of any decision made by the subject(s) and contains in its storage the empirical data and/or the analytical capability of generating comparable data necessary to make these determinations, usually in a probabilistic rather than deterministic manner. Therefore, each subject interacts with the continually changing situation during the play of the particular scenario being studied. The model has been developed and used under contracts with NHTSA, FHWA, DOD, and a number of industrial companies. The model accurately replicates vehicle dynamics and roadway/traffic environments, and also the driver search-response system. An appendix presents results of a simulation run involving driver performance, vehicle parameters, and roadway conditions.

by Louis A. C. Barbarek; Richard L. Chiapetta; Owen J. Viergutz
ITT Res. Inst.
Rept. No. SAE-760791; 1976; 34p 3refs
Presented at Automobile Engineering Meeting, Dearborn, Mich., 18-22 Oct 1976.
Availability: SAE

HS-021 346

DESIGN AND DEVELOPMENT OF A DISC BRAKE CALIPER FOR SMALL CARS

A new lightweight front disc brake caliper design, the 7000 Series, is currently being used on the 1976 Chevrolet Chevette. The lightweight, single piston, sliding caliper design uses only 18 component parts. A short overall length (12.7 mm solid rotor) with a single bolt mounting allows versatility of fitting within restricted environments. Caliper mounting sliding members are well protected from corrosive elements. Braking reaction forces are taken along the cylinder area of the housing in line with friction forces. The caliper slides in a stamped steel bracket which is bolted to a forged steering knuckle. An integral lining wear sensor comes into contact with the rotor surface when the lining becomes worn to a predetermined distance from the shoe. Upon completion of the 7000 series design for the Chevette application, hardware comparisons were made between it and the fixed, two-piston, front disc brake design used on the Opel "Kadet," in addition to numerous validation tests. Serviceability is simplified by using fewer component parts. A free-floating design concept allows the caliper to follow the rotor.

by Charles T. Hoffman
General Motors Corp., Delco-Moraine Div.
Rept. No. SAE-760792; 1976; 10p
Presented at Automobile Engineering Meeting, Dearborn, Mich., 18-22 Oct 1976.
Availability: SAE

HS-021 347

DEVELOPMENT OF A SYSTEM OF COMPARABLE CAR CLASSES FOR FUEL ECONOMY LABELING

Approaches to classification of passenger automobiles have been studied, in order to fulfill requirements of Section 506 of the Energy Policy and Conservation Act for the labeling of 1977 and later model year cars with fuel economy information for the individual car and other "comparable cars" in its class. Weight, wheelbase, price, fuel economy, performance, exterior size, interior passenger space, and cargo (trunk) volume are possible parameters for establishing car classes. To facilitate data handling, computer programs were developed to rank a representative sample of approximately 150 domestic and foreign vehicles of the 1976 new car fleet and sort them into classes. Interrelationship of parameters, relevance to buyer perception and vehicle utility (as measured by exterior and interior volume), and traditional marketing patterns were used as the basis for selecting interior volume as the class index parameter. A system with five classes for cars and three classes for station wagons based on the interior volume index related well to vehicle utility and will be applicable to future vehicles. Success of the system as a tool to encourage the purchase of fuel-efficient vehicles is yet to be determined. The classification system provides a new and useful analytical tool for evaluating the nature of, and changes in, new car design with emphasis on "design efficiency." Appendices include excerpts from SAE recommended practice regarding motor vehicle dimensions, listings of data base, and parametric analyses of vehicle classes.

by Barry D. McNutt; Diane Pirkey; Robert Dulla
Federal Energy Administration
Rept. No. SAE-760794; 1976; 41p 23refs
Presented at Automobile Engineering Meeting, Dearborn, Mich., 18-22 Oct 1976.
Availability: SAE

HS-021 348

FUEL CONSUMPTION IN EUROPEAN PASSENGER CARS POWERED BY GASOLINE, DIESEL, AND DIRECT INJECTION STRATIFIED CHARGE ENGINES

A comparison of fuel consumption of a typical European passenger vehicle powered by gasoline, diesel and stratified charge engines (SCE's) having performance characteristics allowing equal vehicle acceleration shows that, on the average,

the gasoline and diesel fuel consumption are similar, while with the SCE a benefit of from 7% to 20% is observed. Compliance with European regulations is the main exhaust emission constraint within the study. Comparisons are made using a computer simulation. A medium European passenger car powered both by a diesel or by a SCE could attain the same acceleration performance as that powered by a current gasoline engine having nearly half the displacement. If diesel or SCE having 2.0 to 2.5 liters displacement are considered, the acceleration performances are much poorer than those which similar (in weight and dimensions) gasoline-engined cars normally achieve. Average fuel consumptions of gasoline and diesel-powered cars are similar, but the lowest possible diesel car fuel consumption, compared with the lowest possible fuel consumption of the equivalent gasoline engined car is similar during cruise operation, but could be lower (4% to 15%) during urban operations. A specific fuel consumption forecast of a SCE for passenger cars made in two different ways revealed that the SCE engine could attain excellent specific fuel consumptions when compared both with current diesel and gasoline engines. An appendix shows fuel consumption maps for current diesel gasoline and stratified charge engines.

by A. Ciccarone; C. Antonini; U. Virgilio
Alfa Romeo Res. Dept., Italy
Rept. No. SAE-760796; 1976; 18p 11refs
Presented at Automobile Engineering Meeting, Dearborn, Mich., 18-22 Oct 1976.
Availability: SAE

HS-021 349

A LABORATORY APPROACH TO AUTOMOBILE CRASH EXPERIMENTS

An investigation into the crash phase of full-size automobile intersection collisions uses analytical and experimental methods to show that the automobile crash phenomena may be explained macroscopically by rigid body impact theory. Analysis of experimental results indicates the numerical range of the coefficient of friction between the colliding vehicles and the coefficient of restitution necessary to explain the crushing characteristics of the automobile structures and the final velocities at the end of the crash phase for different modes of intersection collisions. The intact portion of the vehicle during collisions may be considered a rigid body and the kinetic energy of involved vehicles just before the collision is absorbed primarily by the crushed portion of the vehicle. Deformation is small compared with overall vehicle dimensions. The coefficient of friction between two vehicle bodies is approximately 0.4 and the coefficient of restitution is practically zero. Although only an approximate agreement was obtained between model and full-size collisions, experiments conducted with model-size vehicles indicated that many facets of automobile collisions may be studied less expensively and more uniformly in the laboratory.

by Haluk Bekiroglu
Southern Illinois Univ.
Rept. No. SAE-760798; 1976; 8p 8refs
Presented at Automobile Engineering Meeting, Dearborn, Mich., 18-22 Oct 1976.
Availability: SAE

HS-021 350

DEVELOPMENT OF A MOVABLE DEFORMABLE CRASH BARRIER

Basic differences exist between automobile tests with a rigid barrier versus tests with a moveable deformable crash barrier. A design goal for the trapezoidal force-deflection characteristic, which must be nearly independent from impact speed, also requires independence of the deformation force of the energy absorbing element from deformation velocity. Kinetic energy of the moving deformable barrier is absorbed simply: impact loads face a friction-cone, which is connected with the front plate of the barrier, into a metal tube. Consequently the tube diameter increases due to plastic deformation of the tube material, absorbing about 75% of the energy. Cutting the frangible tubes absorbs the other 25% of kinetic energy. The boil/buckling phenomenon is used for energy absorption. Preliminary test results show that the system works nearly independently of impact velocity. Influences of energy capacity by temperature are negligible for a range from -20° C to 030° C.

by Ulrich Seiffert; Ruediger Weissner
Volkswagen AG, Germany
Rept. No. SAE-760797; 1976; 8p 3refs
Presented at Automobile Engineering Meeting, Dearborn, Mich., 18-22 Oct 1976.
Availability: SAE

HS-021 351

CADAVER AND DUMMY KNEE IMPACT RESPONSE

Knee impacts along the femoral axis of unembalmed male cadavers and Part 572 dummies have been made with rigid pendulum impactors to determine if the rigid metal skeleton of the Part 572 dummy, which comprises the bulk of its body weight, could cause differences in knee impact response compared to the human whose weight is primarily contained in less rigid materials (flesh, fluids). The dummy exhibits significantly higher knee impact forces than the cadaver subjects. This difference of response is shown to be due to differences of effective leg mass and knee padding. The dummy with its heavy rigid metal skeleton is not like its human counterpart, where the majority of the leg weight is composed of loosely coupled flesh. Knee impacts of dummy subjects show that the dummy femur transducer force is consistently less than the corresponding dummy knee impact force by a constant ratio of 0.8. Recommendation is made that the "skeletal" weight of the Part 572 dummy leg should be substantially reduced, with the weight difference being added to a properly simulated leg flesh. The simulated flesh covering of the knee should be modified to reduce the peak force resulting from rigid body impacts.

by J. D. Horsch; L. M. Patrick
General Motors Corp.; Wayne State Univ.
Rept. No. SAE-760799; 1976; 16p 7refs
Presented at Automobile Engineering Meeting, Dearborn, Mich., 18-22 Oct 1976.
Availability: SAE

HS-021 352

EFFECT OF ENERGY AND EMISSION CONSTRAINTS ON COMPRESSION RATIO

The relationship of compression ratio to fuel energy conservation has been evaluated with the constraint of 1977 Federal emission standards. The influence of the energy losses in the refinery process to produce higher octane fuels is considered as well as the effect of compression ratio on engine efficiency. Two different emission control systems are evaluated: a catalytic converter-exhaust gas recirculation (EGR) system and a manifold reactor-EGR system. These systems are evaluated on six vehicles; three intermediate size with 350 CID engines at compression ratios of 7.4, 8.3, and 9.2:1 and three subcompact size with 151 CID engines at the same three compression ratios. Based on total energy conservation, there does not appear to be an incentive for increasing unleaded or leaded fuel octane levels to allow for the use of higher compression ratios with converter-EGR or reactor-EGR control systems at the 1977 Federal emission standards. Although fuel economy is improved, the result is higher octane requirements. Substantial refinery energy losses occur when producing unleaded fuels with octane levels higher than 91 research octane. In addition, the catalytic converter-EGR system appears to provide equal to or improved energy utilization compared to the reactor-EGR control system.

by James J. Gumbleton; George W. Niepoth; James H. Currie
General Motors Corp., Engineering Staff
Rept. No. SAE-760826; 1976; 19p 16refs
Presented at Automobile Engineering Meeting, Dearborn, Mich., 18-22 Oct 1976.
Availability: SAE

HS-021 353

AUTOMATIC ADJUSTERS FOR PASSENGER CAR DISC BRAKES

An adjuster has been developed for passenger car disc brakes which is well protected from pad knockback effects, and also provides load insensitivity without the customary use of an extra hydraulic seal. Accurate adjuster clearance improves parking brake effectiveness with any operating system and more than doubles the advantage which can be gained from variable velocity ratio linkages. A new "one shot" adjuster (described in appendices) provides load-insensitivity without using an extra hydraulic seal. In the context of parking brake adjusters, knock-back can be defined as an effect which tends to increase the adjuster clearance by violent relative movements of the caliper and rotor. The most important causes of knock-back are caliper vibration and axle deflection causing the rotor to "wobble" between the pads. The use of load-insensitive adjusters with good knock-back resistance can only produce a direct P.V. reduction of up to 30% but it also significantly improves the ability of variable velocity ratio devices to reduce further the P.V. Total reductions of 60% do not seem unreasonable compared with fixed ratio load-sensitive systems. A given amount of knock-back absorbs a larger proportion of the travel reserves when the adjuster is load-insensitive than when it is not. Knock-back resistance therefore assumes even greater importance with these adjusters than with the load-sensitive variety. Appendices detail two knock-back tests, severe and less severe, and a drive ring adjuster.

by A. W. Harrison
Girling Ltd.
Rept. No. SAE-760786; 1976; 11p
Presented at Automobile Engineering Meeting, Dearborn, Mich., 18-22 Oct 1976.
Availability: SAE

HS-021 354

STRUCTURAL ANALYSIS OF AUTOMOTIVE BRAKE DRUMS

Distortion and stresses in brake drums are investigated in relation to applied loads. The analytical technique employs the thin-shell theory due to V. V. Novozhilov in an orthotropic shell-of-revolution computer program by means of which the governing differential equations are solved with finite-difference mathematics. Deformities and stresses in brake drums can be predicted by analytical technique. Good agreement is obtained in a comparison between predicted radial drum deflections and corresponding experimental measurements carried out for a special laboratory loading configuration. Results serve to confirm the applicability of the theory of thin elastic shells to the structure of the typical automotive brake drum. Magnitudes of deflections and stresses in brake drums have been shown to depend very much on the geometrical configuration of the labyrinth seal. Although the design is usually predicated upon heat transfer rather than structural considerations, design variations of the labyrinth seal have been found to be the most significant factor affecting drum stiffness in production versions of brake drums. Drum design tends to have a greater influence upon stiffness and strength than do material properties. Because of inherent variability, the modulus of the cast iron used in the drum analysis must be carefully determined. The first three lower order harmonic response terms (influence coefficients) can be used to provide a kind of "fingerprint" of drum stiffness. The stiffening effect of an attached ring such as the labyrinth seal is most significant in the lower-order nonzero harmonic response terms.

by Robert C. Petrof
Ford Motor Co., Engineering and Res. Staff
Rept. No. SAE-760788; 1976; 19p 8refs
Presented at Automobile Engineering Meeting, Dearborn, Mich., 18-22 Oct 1976.
Availability: SAE

HS-021 355

A DATA ACQUISITION METHOD FOR DYNAMIC VEHICLE TESTING

A Mobile Telemetry Instrument Facility (MTIF) has been developed and used for acquisition of dynamic vehicle test data. Objectives of the MTIF are maximum flexibility, highest degree of accuracy, and quickest response during dynamic test activities. Information derived from test activities is used in design and development of trailers, trailer hitches, hitch attachment points to tow vehicles, and braking systems. The EMR Schlumberger Telemetry system is used. The MTIF is housed in a 26-foot motor home shell. The interior layout resembles the cabin of a space vehicle. A generator in the rear

signals from the test vehicle are received by a custom-mounted, reinforced antenna at the front of the van. The signal is demultiplexed and branched to the proper instruments. A test entails setting parameters, making instrument settings, calibrating, running the test, and postcalibrating. Six patch panel programming boards allow for a wide range of test situations without time consuming set-up procedures. A magnetic tape data recorder electrically stores the data channels from the telemetry system or other data sources. A radio transducer provides constant intervehicle communication and, while within range, communication with the base test center. All instrumentation can be tested and calibrated on board the MTIF.

by John C. Abromavage; Richard L. Beemer
Amerco Technical Center
Rept. No. SAE-760789; 1976; 10p 7refs
Presented at Automobile Engineering Meeting, Dearborn, Mich., 18-22 Oct 1976.
Availability: SAE

HS-021 356

MICROPROCESSORS PERFORM ENGINE CONTROL FUNCTIONS

A development program has been formulated to implement digital engine controls with microprocessors; its key elements are designed to obtain a cost effective large scale integration (LSI) integrated circuit set. The digital engine control system provides control in automotive engines for spark timing, exhaust gas recirculation, and fuel control. A microprocessor controls the ignition and fuel flow for optimal engine performance. Special input/output circuits are required to interface the microprocessor to the engine and throttle sensors and actuators; the circuits can be designed to control the engine in the event of microprocessor failure. The partitioning of electronic functions permits the system to achieve incremental cost reductions and/or performance increases resultant from semiconductor technology advances. A typical development program would have five phases, the first being initial bench breadboards and software development. The second phase, a vehicle mounted system model, would provide for an early evaluation of the total control concept. Phase three would establish system design of a microprocessor chip set, while during phase four the production chip set would be finalized. The fifth phase would cover advanced system integration. NMOS technology is superior for use in microprocessor and memory development. The dual slope integration method appears to be best suited for NMOS ADC circuitry. Production time for microprocessor engine controls is at least a two-year cycle. A proposed development schedule is presented, which includes all key events.

by G. Novis; J. Bryant
Texas Instruments Inc., Semiconductor Group
Rept. No. SAE-770005; 1977; 23p
Presented at International Automotive Engineering Congress and Exposition, Cobo Hall, Detroit, 28 Feb-4 Mar 1977.
Availability: SAE

HS-021 357

ACCIDENT AND SPEED STUDIES IN CONSTRUCTION ZONES. FINAL REPORT

Results of two studies of construction-zone traffic control are presented. The first study involved analysis of traffic accidents occurring in 79 construction zones in seven states. Results show that the zones experienced an average increase in accidents of 6.8%; however, 31% of the projects studied experienced decreased accident rates during construction (assuming that before and during traffic volumes are equal). Twenty-four percent of the projects experienced rate increases of 50% or more. Results are also presented for breakdowns by accident types, severity, light conditions, roadway type, area type, work area roadway type, construction type, and state. The second study was field testing of speed reduction methods. Speeds, erratic maneuvers, and conflicts were measured at three sites (urban freeway, rural freeway, urban street). Results of the urban freeway and rural freeway studies are included. Results of the urban street studies will be included in a special report on taper studies due for completion in Aug 1977. The field studies examined the effect of the following construction zone parameters on vehicle speeds and safety: speed zoning (advisory and regulatory), sequential flashing arrow boards, enforcement, transverse striping, obliteration of nonappropriate pavement markings, taper length, lane width reduction, and active warning of speed zoning. Recommended guidelines for construction zone controls are also included.

by J. L. Graham; R. J. Paulsen; J. C. Glennon
Midwest Res. Inst., 425 Volker Blvd., Kansas City, Mo. 64110
Contract DOT-FH-11-8121
Rept. No. FHWA-RD-77-80; 1977; 233p 61refs
Rept. for Dec 1975-Jun 1977.
Availability: NTIS

HS-021 358

EFFECTIVENESS OF HIGHWAY ARTERIAL LIGHTING. FINAL REPORT

A cost/benefit analysis of arterial highway lighting treatments in terms of traffic safety and energy usage is presented. The results have shown that total nighttime dry weather accidents are inversely related to visibility, higher visibility resulting in fewer accidents. Areas with high population densities have a much higher rate of accidents than low density areas, and central business district (CBD) areas have a much higher rate than other area types. Regression equations have been developed which predict nighttime accident history based on population density, area type, and visibility. The results have also shown that more cost-beneficial lighting systems can be designed using High Pressure Sodium (HPS) rather than Mercury luminaires although it is normally possible to use either source to obtain systems with benefit-cost ratio greater than 1. When visibility and accident reduction potential are the main constraints, optimum designs tend to use 400 HPS luminaires;

when cost and energy use are the main constraints, 150 HPS luminaires tend to be optimum.

by M. S. Janoff; B. Koth; W. McCunney; M. Freedman; C. Duerk; M. Berkovitz
Franklin Inst. Res. Labs., 20th and Pkwy., Philadelphia, Pa. 19103
Contract DOT-FH-11-8825
Rept. No. FHWA-RD-77-37; FIRL-C4228; 1977; 220p 77refs
Rept. for 1 Sep 1975-15 Jul 1977. Cosponsored by the Federal Energy Administration. See also HS-021 359.
Availability: NTIS

HS-021 359

EFFECTIVENESS OF HIGHWAY ARTERIAL LIGHTING. DESIGN GUIDE. FINAL REPORT

As part of a cost/benefit analysis of several selected urban and suburban highway arterial lighting treatments in terms of traffic safety and energy use, a design guide has been developed to assist potential users in conducting cost/benefit analyses of lighting changes at specific locations. This design guide provides instructions for use by traffic engineers and highway designers in utilizing a computer program to determine visibility on arterial streets and a method for conducting a cost/benefit analysis of lighting systems for new or unlit roadways and of the upgrading of existing lighting systems. The computer program, known as "VI," calculates horizontal and vertical illumination, and the luminance of a target of user-specified reflectance, at each point in a roadway grid defined between two adjacent luminaires and both curb lines. For each target point, a driver's position upstream and a background area downstream are defined. Background luminance of the roadway area which lies behind the target from a driver's line of sight, and veiling luminance produced by each luminaire downstream of the driver are computed for each grid point. The luminance contrast, relative contrast sensitivity of the eye to the background luminance, relative contrast sensitivity to background plus veiling luminance, a disability glare factor, and visibility index are calculated for the simulated driver that is associated with each grid point. The mean, standard deviation and 15th percentile values of the grid array of each of these parameters may also be calculated as an option. Two options are open to the user within the structure of the VI program. An analysis package provides the user with a method of judging the effectiveness of the existing lighting conditions of the arterial of interest. A design package provides the user with a technique for searching out the most cost effective new system, or evaluating various upgrading options.

by M. S. Janoff; B. Koth; W. McCunney; M. Freedman; C. Duerk; M. Berkovitz
Franklin Inst. Res. Labs., 20th and Pkwy., Philadelphia, Pa. 19103
Contract DOT-FH-11-8825
Rept. No. FHWA-RD-77-38; FIRL-C4228; 1977; 180p 3refs
Rept. for 1 Sep 1975-30 Apr 1977. Cosponsored by the Federal Energy Administration. See also HS-021 358.
Availability: NTIS

HS-021 360

DRIVING IN FOG ON THE M4

Vehicle driver behavior in fog is examined via 1780 vehicle photographs in conjunction with visibility level monitoring and Orbis III device was used to measure speed and trigger a flash and camera unit which photographed vehicles from the rear, obtaining license number. Speed, date, and time were recorded on each photograph. Equipment was activated each time visibility dropped to 200 meters or less. Questionnaires solicited information on the driver's opinions on conditions in which the vehicle was photographed and on driving in fog generally - 76% were answered. Analysis indicates that the equipment used was adequate at visibilities down to 40 meters. Recorded speeds were generally close to the 70 mph limit, marked reductions occurring only when visibility distances were below 100 meters. Although high speeds were more likely to be adopted by drivers who were familiar with general motorway driving, drivers more familiar with the particular length on which fog occurred were likely to be driving more slowly. Speeds were apparently consciously adopted, to the extent that those drivers traveling at higher speeds were aware of travelling faster than other vehicles. Drivers' safety margins decreased with decreasing visibility. At 50 meters visibility more than half the drivers were exceeding the speed at which they could stop within this distance; the shortest braking distances given in the Highway Code being assumed which refer to good, not poor, conditions. The two primary factors affecting speed are visibility and advisory speed signs. It appears that there could be benefit from advisory speed signs which are more closely related to fog conditions. An appendix presents data on accident histories on English motorways between 1970 and 1975.

by R. Sumner; C. Baguley; J. Burton
Transport and Road Res. Lab., Road User Characteristics Div., Crowthorne, Berks., England
Rept. No. TRRL-SR-281; 1977; 24p 3refs
Availability: Corporate author

HS-021 361

ENERGY, AIR POLLUTION, DELAY, AND SAFETY EVALUATION OF NON-SIGNALIZED CONTROL AT LOW VOLUME INTERSECTIONS. FINAL REPORT

An energy, pollution, delay, and safety evaluation was made of nonsignalized control at low volume intersections with the objective of selecting, on the basis of a systems trade-off, the most efficient control technique. This research accomplished that objective with the aid of computer simulation, field observation, and traffic records. The Federal Highway Administration's (FHWA) Urban Traffic Control Simulation (UTSC) was modified to permit close study of the velocity patterns created by automobiles traversing an intersection from the controlled (signed) approaches. Utilizing an adapted version of the Environmental Protection Agency's (EPA) Automotive Exhaust Emission Modal Analysis Model, appropriate UTSC output was examined to compare gasoline consumption and air pollution resulting from stop, yield, or no sign control across a range of traffic volumes. The analyses showed a significant increase in carbon monoxide emissions and gasoline use with increasingly positive control. Sign type was found to have only secondary effects on hydrocarbon and nitrogen oxide emissions. The simulation output also aided the travel time-delay comparison. Stop signs were found to require an average of four seconds more travel time per vehicle than did yield control. Laboratory analysis of field-gathered data permitted a test of the noise generated by traffic in the vicinity of stop as compared to yield control. Although a 1 to 2 dBA increase due to stop signs was apparent, the difference was not considered

was of major importance in this study. It was found that the likelihood of an accident at a low-volume intersection to be very small regardless of control type. Systems analyses permitted trade-offs comparing the safety advantages against the air pollution, gasoline, and travel time disadvantages associated with increasingly restrictive intersection control. These efforts gave preliminary support to yield signs as the optimal low-volume crossing control, this being further substantiated by a benefit-cost study. Totaling the cost (gasoline, delay, other operating outlays, accidents) pertaining to each control indicated the yield sign to provide the most efficient alternative at adequate sight distance intersections for daily volumes of 200-800, while no sign at all is the most cost effective measure at lower volumes. A set of guidelines is presented, based upon this analysis, to aid in the selection of the optimal control for any given low-volume intersection.

by Dana L. Hall
Purdue Univ., Hwy. Extension and Res. Proj., West Lafayette, Ind.
Rept. No. CE-TRA-77-1; 1977; 274p 113refs
Availability: Corporate author

HS-021 362

TRAFFIC SPEED REPORT NO. 101. INTERIM REPORT

Study of free-flowing automobile and truck speeds on rural, tangent, level sections of interstate, four-lane, two-lane, and on urban interstate highways in Indiana shows that overall average speed for passenger cars and all trucks was 58.1 mph and 58.0 mph respectively. Average speed of passenger cars was similar while that of trucks was 2.0 mph greater than the respective average speeds for the preceding quarterly period. For the first time since initiation of speed studies in Indiana, average speed of heavy trucks (58.6 mph) exceeded that of passenger cars (58.1 mph). All observations were made during daylight and under favorable conditions, by Radar Speed Meters. All collected and analyzed data are included in appendices in tabular form.

by G. S. Toft; G. K. Stafford
Purdue Univ., Joint Hwy. Res. Proj., Civil Engineering Bldg., West Lafayette, Ind. 47907
Grant HPR-1(15)
Rept. No. JHRP-77-16; 1977; 46p
Rept. for Apr-Jun 1977.
Availability: NTIS

HS-021 363

LEGAL IMPLICATIONS OF REGULATIONS AIMED AT REDUCING WET-WEATHER SKIDDING ACCIDENTS ON HIGHWAYS

Legal implications of the wet-weather skid reduction program and the recommended minimum pavement skid resistance are investigated. General principles of liability of state highway departments for failure to design, construct, and maintain highways with safe skid resistance are outlined in anticipation of a Federal program aimed at reduction of skidding accidents on highways. Such a program implies various state liabilities. At present the regulations grant the states considerable discretion in choosing the most suitable pavement or the most desirable material to reduce wet-weather skidding accidents. In areas of measurement techniques, use of accident data, and identification of hazardous wet-weather locations through a general inventory, the regulations are becoming more specific; however, they are advisory rather than required. To date, cases suggest strongly that accident data prior to an accident that identify locations prone to wet-weather skidding accidents would be admissible on the issues both of the state's notice and of the hazardous nature of the highway. Subsequent accident data would be admissible only on the question of the highway's hazardous condition. Wet-weather skid-reduction regulations would be themselves admissible, particularly if they have the force of the law. Where the regulations were general and discretionary in nature, they would constitute some evidence of negligence where the regulations were either not adhered to or given scant attention. However, where there is a failure to comply with a specific mandatory requirement, violation of the regulation could be held to be negligence per se, thereby stamping the defendant's conduct as negligent. A general inventory of hazardous wet-weather skid locations could be a basis for a claim that any highway not in compliance was ipso facto hazardous and that the state has an immediate duty to correct the condition. Cases suggest however, that the state's decision on which highways to correct first is discretionary, and that to impose such a rigid duty is unreasonable.

Publ: Research Results Digest n95 (Aug 1977)
1977; 32p refs
Based on "Right-of-Way and Legal Problems Arising out of Highway Programs" by Larry Thomas, Transportation Res. Board.
Availability: National Res. Council, Transportation Res. Board, Washington, D.C.

HS-021 364

SKIDDING ACCIDENTS. TIRES, VEHICLES, AND VEHICLE COMPONENTS

A conference forum for international exchange of information on all aspects of wet-weather skidding accidents on highways included presentation of 17 papers on influence of tires, vehicles, and vehicle components in skidding accidents. Operational or in-use variables are deemed likely to be far more consequential in controlling the potential for skidding than differences in design practice. Analysis of tire skid resistance in several operating modes indicated that skid numbers do not adequately describe skid resistance of tires. Breakaway of a vehicle from a controlled course is preventable via vehicle design of brake systems, for example. Front suspension geometry and splitting of dual brake circuits can be designed to achieve optimal braking stability both on a straight course and when cornering. Instrumentation systems of passenger tire skid trailers have advanced quite a lot, with digital integration techniques being the most advantageous for data use and storage. Mobile apparatuses have been constructed and employed to evaluate the shear forces produced by pneumatic tires on actual paved surfaces. The Calspan Tire Res. Facility (TIRF) has been used to evaluate skid resistance properties of tires on wet road surfaces. Japan has developed numerous traction measuring methods for outdoor and indoor evaluation of braking and cornering traction. European measurement techniques have been developed to investigate tire/road friction and potential improvements. Antilock braking systems have been developed which allow quick stops without loss of directional control. Torque characteristics of commercial vehicle brakes can be modeled and made part of a hybrid computer simulation of an antilock system. Tread composition variables directly affect wet friction of tires. Influence of tread

pattern on tire wet traction can be measured by the locked-wheel traction coefficient. Tread depth of tires affects skidding accident potential, a fact resulting in minimum international legislation. Radial construction itself is not inherently advantageous for straight ahead wet traction. Mathematical analysis of the influence of tread pattern on tire performance results in a more definitive operational severity equation. Of the operating conditions influencing skid performance of tires, speed and water depth interacted, with speed the dominant variable for both peak and slide on flooded surfaces.

National Acad. of Sciences, Transportation Res. Board, 2101 Constitution Ave., N.W., Washington, D.C. 20418
Rept. No. TRR-621; 1977; 178p refs
Proceedings of the Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977. Abstracts in French and German.
Availability: Corporate author $7.00

HS-021 365

TIRE-VEHICLE SYSTEM ELEMENTS BEARING ON THE PROBABILITIES OF LOSS OF CONTROL

Examination of the interrelationship of the tire-vehicle system with the driver/vehicle/roadway system shows that it is not possible to isolate "friction demand" and "friction available" as separate, distinct entities; but that it is feasible to identify "skidding" as a loss of control event in which the "maneuver outcome" departs from the "maneuver demand." Skidding is a random event in which the probability of occurrence has some minimal value and increases above some minimum, depending upon drivers, roadways, vehicles, and the weather. Maneuver demand, defined as the demand for tire/road friction levels which are sufficient to generate the required forces, is helpful in determining the necessary level of pavement skid resistance. Operational or in-use variables are likely to be far more consequential in controlling the potential for skidding than differences in design practice. Antilock brakes as a skidding countermeasure relieve the driver of some responsibility for modulating brakes on slippery surfaces. However, they are too costly to become a mandatory installation at this time. Future vehicle design, such as increased ratios of side area to weight, indicate increased sensitivity to crosswinds. Increased maneuvering-induced loads and reduced maneuvering limits on dry and wet roads are likely with greater popularity of small cars.

by Leonard Segel
University of Michigan
Publ: HS-021 364 (TRR-621), "Skidding Accidents. Tires, Vehicles, and Vehicle Components," Washington, D.C., 1977 p1-7
1977; 6refs
Presented at Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 364

HS-021 366

SKID RESISTANCE PROPERTIES OF TIRES AND THEIR INFLUENCE ON VEHICLE CONTROL

Skid resistance of tires and vehicles is analyzed in several operating modes: braking, accelerating, cornering, and their combination, indicating limitations of skid numbers. Skid numbers provide only a relative measure of road surface skid resistance and do not describe the skid resistance of tires used on motor vehicles. Tire skid resistance characteristics can be defined as a relationship between braking (driving, cornering) coefficient and wheel slip or slip angle, within the range of the coefficient between its peak and slide values. Skid resistance characteristics show a transition from a peak value of force coefficient reached at critical slip to a slide value reached at 100% slip. The concept of peak and slide traction envelopes as boundaries of tire skid resistance characteristics can be used in analyzing skid resistance characteristics of a tire in cornering with braking or driving torque application. Within a slip angle range between 20° and 90°, lateral force measured on a free rolling tire decreases with an increase in slip angle; however, force measured on a locked wheel increases. The lateral force coefficient of a locked wheel increases with an increase of slip angle until it reaches the value of this coefficient for a free rolling wheel at a 90° slip angle. Tire skid resistance characteristics provide a foundation for computer simulations of vehicle handling at performance limits. Vehicle skid resistance characteristics are influenced by brake features including proportioning valves and anti-skid systems, and also by vehicle design factors affecting vehicle understeer.

by Walter Bergman
Ford Motor Co.
Publ: HS-021 364 (TRR-621), "Skidding Accidents. Tires, Vehicles, and Vehicle Components," Washington, D.C., 1977 p8-18
1977; 9refs
Presented at Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 364

HS-021 367

VEHICLE DESIGN AND SKID RESISTANCE

Prevention of breakaway of a vehicle from a controlled course and assured short stopping distances on slippery roads can be approached via vehicle design. Vehicles show a typical behavior when reaching the limits of breakaway and beyond it. When driving a circular path the steady state driving steering angles of understeering cars increase progressively with increasing speed, whereas steering angles of oversteering cars decrease rapidly after passing a maximum value. For both steering characteristics the torque which is felt at the steering wheel is always passing a maximum followed by the loss of feel for steering response. Behavior of the car when the limiting condition is approached is determined by the location of the center of gravity, the suspension design with its kinematics, springs and shock absorbers, and the tire characteristics. In order to force the breakaway, intensified conditions of driving were applied, individually or combined, such as starting from a circular path steadily enlarging steering angle, sudden lack of skid resistance, and emergency braking. Under these conditions, the vehicle deviates from its intended course and the understeering car continues on a wider circle, whereas the oversteering car turns around its vertical axis. When braking with locked wheels, the center of gravity of the car moves tangentially to the bend. The forces transferred from tire to road and their dependences are significant. The available maximum values of traction coefficients range between 0.1 on ice up to 1.0 on dry surfaces, depending on speed, cornering forces, and braking or traction forces. On wet roads important differences in cornering forces and locked

braking forces are seen for tires of different design but same purposes.

by F. Gauss
Technische Universitat, Hannover, Germany
Publ: HS-021 364 (TRR-621), "Skidding Accidents. Tires, Vehicles, and Vehicle Components," Washington, D.C., 1977 p19-27
1977; 12refs
Presented at Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 364

HS-021 368

DESIGN OF SUSPENSION TO PREVENT PULLING TO ONE SIDE AND SKIDDING DURING BRAKING, PARTICULARLY ON A SURFACE WITH DIFFERING COEFFICIENT OF FRICTION

Front suspension geometry and splitting of dual brake circuits can be designed to achieve optimal braking stability both on a straight course and when corncring. Front suspension geometry incorporating outboard scrub radius (negative lever arm of braking force) together with diagonally split dual brake circuits, especially with wheels on a surface with different skid number, can considerably improve directional stability under braking. Even expensive antilock braking systems do not avoid uneven braking forces, because front wheels are controlled independently of each other. With a front suspension with outboard scrub radius, the wheels will take up a stable position, applying steering correction. Full braking compensation can be achieved even with very inelastic steering designs. Experiments show that correcting forces needed at the steering wheel in the case of outboard scrub radius are only one fifth of the steering torques required in the case of inboard scrub radius. The oversteer/understeer behavior of a vehicle incorporating outboard scrub radius changes only slightly: this applies not only to straight ahead motion but even to cornering motion when one diagonal brake circuit fails.

by Detlef Banholzer
Volkswagenwerk, Wolfsburg, Germany
Publ: HS-021 364 (TRR-621), "Skidding Accidents. Tires, Vehicles, and Vehicle Components," Washington, D.C., 1977 p28-33
1977
Presented at Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 364

HS-021 369

ASTM [AMERICAN SOCIETY FOR TESTING AND MATERIALS] SKID TRAILERS. INSTRUMENTATION SYSTEMS THRU COMPUTERIZATION

Over the past 20 years, instrumentation systems of passenger tire skid trailers have changed from vacuum tube amplifiers to solid state, from pen recorders to light beam, and fiber optic oscillographs to digital tape. A new approach to acquisition of skid data involves installation of programmable calculators or minicomputers with the proper digital interfaces to sample the analog data. Peak and SN's or coefficients are then calculated directly from the sampled data. Digital integration techniques are advantageous compared with conventional analog techniques in that stored data can be recalled, processed, and later used to draw horizontal and vertical force curves, speed and percent slip each versus time in addition to mu-slip. Research has indicated that static calibration on a platform is not too meaningful, and that a dynamic calibration platform more closely simulates tests on road surfaces.

by Richard D. Van Arnam; Douglas C. Domeck
Smithers Scientific Services, Inc.
Publ: HS-021 364 (TRR-621), "Skidding Accidents. Tires, Vehicles, and Vehicle Components," Washington, D.C., 1977 p34-42
1977; 3refs
Presented at Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 364

HS-021 370

MEASUREMENT OF SHEAR FORCES DEVELOPED BETWEEN TIRE AND PAVEMENT

Mobile apparatuses have been constructed and employed to evaluate the shear forces produced by pneumatic tires on actual paved surfaces. These devices have permitted extensive examination of tires designed for service on passenger cars and on light and heavy trucks. The mobile machines impose a set of controlled operating conditions on a tire specimen while the entire machine travels across a specimen pavement. They are usually applied to the examination of high slip phenomena which pertain to severe cornering and braking maneuvers of vehicles. All mobile tire traction dynamometers incorporate a foundation vehicle whose function is to tow, direct, and support the tire-locating apparatus as it travels. They have been constructed in the forms of unit vehicles, or tow vehicle and trailer. The mass directly supported on the tire spring must be minimized, thus maximizing the natural frequency of the wheel hop system. Oval-type test facilities are usually best. The Hwy. Safety Res. Inst. (HSRI) has done extensive research on tire pavement coupling, using a mobile tester for passenger car tires consisting of a retracting tire/wheel dynamometer mounted on a modified tandem-axle commercial tractor. Another HSRI machine, the mobile truck tire dynamometer, consists of a tractor, semitrailer vehicle which permits investigation of either longitudinal or lateral traction characteristics of heavy truck tires. Testing usually involves the comparative evaluation of a sample of specimens which exhibit at least one common design feature.

by Robert D. Ervin
University of Michigan
Publ: HS-021 364 (TRR-621), "Skidding Accidents. Tires, Vehicles, and Vehicle Components," Washington, D.C., 1977 p43-54
1977; 20refs
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Availability: In HS-021 364

HS-021 371

MEASURING SKID RESISTANCE OF PASSENGER CAR TIRES ON AN INDOOR FACILITY

Skid resistance properties of three typical passenger car tires (a bias ply, a bias belted, and a radial ply tire of the G78-14 size series) were measured on a wet road surface. Tests included straight ahead braking at three speeds and three inclination angles, braking and driving in a turn over a wide range of slip angles, and free rolling cornering and camber. Tests were

performed at the Calspan Tire Res. Facility (TIRF) which is characterized by the tire, wheel system, force sensing balance, wheel disc brake, and wheel drive motor, all mounted on a moveable head assembly. Two six-component strain gage balances are available for measuring tire forces and moments. The 28-inch wide roadway is comprised of a stainless steel belt covered with a material that simulates the microsurface texture and frictional properties of actual road surfaces. Results are presented in the form of plots to demonstrate the capability of the test facility and to show the influence of speed, slip angle, inclination angle, and tire construction on the skid characteristics of passenger car tires. Results show a general trend of slip angle variations over the entire test range for the bias belted tire. Values of tractive force under full wheel lockup and full driving conditions did not vary with slip angle. Peak values did change, however, and at times it became difficult to define a peak in tractive force characteristics. As slip angle increased, the slip ratio at which peak tractive force occurred increased. The value of peak tractive force also decreased with increasing slip angle. General trends also apply to radial and bias tires.

by I. Gusakov
Calspan Corp.
Publ: HS-021 364 (TRR-621), "Skidding Accidents. Tires, Vehicles, and Vehicle Components," Washington, D.C., 1977
p55-66
1977; 4refs
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Availability: In HS-021 364

HS-021 372

A CONSIDERATION OF TIRE-ROAD TRACTION MEASURING METHOD IN JAPAN

Numerous traction measuring methods have been used in Japan, including measurement of stopping distance, deceleration of a car when braking force is applied, and braking force or torque obtained by an instrumented towed trailer or a vehicle with wheel for measuring braking traction. Cornering traction is measured via a test for maximum speed at which a tethered or nontethered car being driven in a circle at increasing speed looses control. It is also measured by the relationship between cornering or lateral force and slip angle obtained by a towed trailer or a vehicle with a fifth wheel. Indoor testing methods are used such as an inside surface drum tester to study hydroplaning problems. Tire-road traction mechanisms are sometimes driven on public roads to evaluate tires' market suitability, or to research traction problems. Testing should account for subjective feelings of the driver in relation to ease of driving control. A newly developed tire traction testing vehicle is used to evaluate the relationship between the longitudinal coefficient and the slip ratio, and between the cornering force or self-aligning torque and the slip angle of a free rolling tire. The testing vehicle consists of two devices mounted in a high speed bus, to measure both driving and braking traction, and cornering traction.

by Yukio Maeda
Yokohama Rubber Co., Ltd.
Publ: HS-021 364 (TRR-621), "Skidding Accidents. Tires, Vehicles, and Vehicle Components," Washington, D.C., 1977
p67-74
1977; 20refs
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Availability: In HS-021 364

HS-021 373

AN OVERVIEW OF EUROPEAN MEASURING METHODS AND TECHNIQUES

Various techniques and measuring methods are used in Europe to investigate tire-road friction and ways of improving it, particularly on wet roads. Road friction measurements of wet roads are conducted in Europe by institutions involved in road research and road construction. Automobile and tire industries most often conduct dry-road tests of directional stability of vehicles, and friction coefficients and cornering forces of tires, as well as their influence on directional control properties of vehicles. Investigations of tire/road friction on wet roads are conducted by auto and tire industries to test tire quality; tests are usually carried out in steady state cornering on circular paths at the vehicle's breakaway limits. Road skid resistance is measured by one of three methods: measurement of braking force with one or more braked wheels locked or with forced slip; measurement of side force with one or more wheels which run at side slip at a fixed slip angle; or measurement of braking deceleration by measuring stopping distance with front wheels locked. Reproducibility of measurement results has been improved by standardization of a measuring tire and constant depth of water film during testing. Indoor drum test machines have been developed which can avoid the inconsistencies of outdoor testing.

by Hanns P. Zoeppritz
Publ: HS-021 364 (TRR-621), "Skidding Accidents. Tires, Vehicles, and Vehicle Components," Washington, D.C., 1977
p75-82
1977; 35refs
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HS-021 374

WHEEL LOCK CONTROL STATE-OF-THE-ART

Current systems for preventing continuous wheel lock-up during vehicle braking have developed in sophistication by design changes which allow quick stops without loss of directional control via automatic maintenance of the right brake pressure for the prevailing driving and load conditions. Wheel lock control systems now automatically reduce brake pressure to the wheel if an impending wheel lock-up is detected. The antilock system typically includes three major components: brake pressure modulator, electronic control module, and wheel speed sensor. The systems modulate brake pressure as long as the driver demands excessive brake torques (or until a low vehicle speed is reached, typically below 10 mph); this allows more controllable and stable stops with various road and load conditions. As the wheel lock control system prevents continuous wheel lock-up, the system allows the vehicle operator better to utilize the available lateral forces at the road/tire interface. As such, the wheel lock control system is a driver aid that allows the vehicle operator to retain directional stability and braking effort under many road and load conditions. Brake sizing and balance for a vehicle, load distribution, and tire characteristics

are vehicle parameters which influence operation of the wheel lock control system.

by Robert A. Grimm; Richard J. Bremer
General Motors Corp., AC Spark Plug Div.
Publ: HS-021 364 (TRR-621), "Skidding Accidents. Tires, Vehicles, and Vehicle Components," Washington, D.C., 1977
p83-9
1977; 7refs
Presented at Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
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HS-021 375

BRAKE MODELING ANTI-LOCK SIMULATION

Torque characteristics of commercial vehicle brakes can be modeled and made part of a hybrid computer simulation of an antilock system. The braking system of a commercial vehicle is an open loop pneumatic-mechanical system with feedback controlled by the vehicle operator. To achieve optimum performance, i.e. short stopping distance and vehicle control, the vehicle operator must be aided by a brake control system which senses wheel velocity and acceleration, and then reduces excessive brake pressure and reapplies controlled brake pressure. Most systems in use today consist of an electronic computer, a solenoid controlled air valve, and wheel speed sensors. Design and analysis of this complex system require a combination of engineering simulation and experimental testing. In the simulation of a commercial vehicle antilock system, three areas are difficult to model: the air valve system, the tire/road interface, and the brake drum/brake shoe interface. System performance verification is carried out by comparing it with customer and Dept. of Transportation (DOT) specifications and requirements over the range of environmental conditions. These include dry, icy, and wet road surfaces, loaded and unloaded vehicles, wedge and cam brakes; brake unbalance; various brake materials; effects of weight transfer; split road surface conditions; road surface transitions; various rates of brake application; variations in battery supply voltage; and with the use of an environmental chamber, high and low temperature operation. Elements that make the study of the air brake stopping problem difficult are a surface friction range of 8 to 1, load variations of 10 to 1, and transitions in brake torques of 8 to 1. Effects of variable pneumatic delays and steering torques must be considered along with the desire to produce a low cost, highly dependable, fail-safe/self-test unit.

by R. D. Blosser
Rockwell International Corp.
Publ: HS-021 364 (TRR-621), "Skidding Accidents. Tires, Vehicles, and Vehicle Components," Washington, D.C., 1977
p90-8
1977; 3refs
Presented at Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 364

HS-021 376

EFFECT OF TIRE CONSTRUCTION VARIABLES ON PASSENGER TIRE WET TRACTION

A designed experiment consisting of the three basic tire constructions (diagonal, bias belted, and radial) with three typical tread designs (diagonal type, belted type, and radial type) on each tire construction, is utilized to determine the effect of tire construction on wet traction. Significantly, the radial construction itself does not show an inherent advantage for straight ahead wet traction. This fact is better understood given the interaction between the tire footprint and the road surface. Investigation within the radial construction framework shows variables such as stabilizer ply material and ply angle to have little influence on straight ahead wet traction. Only when the radial construction is coupled with a radial type tread design is the full potential realized. Tire construction may have measurable effects on peak wet traction. It plays a significant role in determining wet cornering potential. However, within any one generic type of construction, a large range of cornering potential may exist. Each of the three typical tire constructions reacted in a similar manner to variations in speed, load, slip angle, and surface. Typical radial tread designs in use today contribute more to the wet traction potential of a tire than the radial construction. If radial type tread design were produced on a diagonal carcass, however, poor mileage to tire wear out could be expected. A careful combination of radial construction and radial tread design is necessary to obtain maximum wet traction performance.

by J. D. Kelley; A. G. Speyer
Firestone Tire and Rubber Co.
Publ: HS-021 364 (TRR-621), "Skidding Accidents. Tires, Vehicles, and Vehicle Components," Washington, D.C., 1977
p99-106
1977; 6refs
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Availability: In HS-021 364

HS-021 377

EFFECTS OF TREAD COMPOSITION ON WET SKID RESISTANCE OF PASSENGER TIRES

A survey of state of the art of tread composition as a factor in tire friction shows the relationship between composition variables and wet friction of tires. Natural rubber and various synthetic rubbers of differing physical properties have been evaluated in a range of tread compounds differing also in extender oil and carbon black contents. Results show that compounds having high hysteresis also have higher coefficients of friction than low hysteresis compounds. Wet skid resistance of practical tread compounds can be varied by the choice of rubber or rubber blend, amount of extender oil, and type of carbon black, listed in order of decreasing effectiveness. Rubbers with higher glass transition temperatures have better skid resistance than rubbers with low transition temperatures. Oil extended rubbers are better than nonextended rubbers. High structure carbon blacks impart more skid resistance than low structure blacks. It is not practical, however, to pyramid all these effects exclusively for skid resistance since the resultant composition would not meet other criteria of acceptable tire performance such as durability and treadwear. Rubbers which are best for skid resistance tend to be poorest for treadwear and vice versa. There are also practical limits for the kind and amounts of extender oil and carbon black that can be used. Modern tread compounds represent judicious choices of composition which satisfy various manufacturing and performance

requirements including high skid resistance and good tread wear.

by Charles F. Eckert
Uniroyal, Inc.
Publ: HS-021 364 (TRR-621), "Skidding Accidents. Tires, Vehicles, and Vehicle Components," Washington, D.C., 1977
p107-12
1977; 16refs
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HS-021 378

TIRE WET TRACTION PERFORMANCE: THE INFLUENCE OF TREAD PATTERN

Influence of tread pattern on tire wet traction is evaluated, as measured primarily by the locked-wheel traction coefficient. A first-order assessment of tire wet traction performance is obtained from a measure of fractional groove volume, defined as the total footprint tread volume that is occupied by the tread groove void. The volume fraction is obtained from the footprint area by use of a reference groove depth of 10 mm. In the 40-60 mph range, the locked-wheel traction coefficient exponentially approaches a limiting or maximum value as the fractional groove volume is increased for straight rib (groove) tires. This maximum value is a function of external factors, mainly pavement texture and water depth. At lower speeds the exponential approach to a limiting locked-wheel traction coefficient is not found. Tires with "zig-zag" groove patterns (groove pitch and throw) show slightly inferior performance to straight rib patterns at the same coefficient values. This is attributed to an increased resistance to front-to-rear water flow through the grooves in the contact patch. It allows a larger fraction of the footprint area to be borne by a thin water film and thus promotes hydrodynamic lubrication. Influence of pavement macrotexture, characterized by its void volume, is very similar to the void volume of the tire tread pattern. Pavement texture numbers proportional to the void were obtained from outflow measurements with a drainage meter. The 45 mph locked-wheel skid coefficient of a standard tire increases in an exponential manner as pavement texture is increased and approaches a maximum value analogous to the behavior with varying tread groove void and a standard pavement. A more definite and realistic operational severity equation is formulated. Five appendices present a list of terminology and nomenclature; test procedures used for wet traction measurements; procedure for measuring water depths on tire traction skid surfaces; a characterization of groove "zig-zag" geometry; and pavement drainage measurement for macrotexture characterization.

by A. G. Veith
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Publ: HS-021 364 (TRR-621), "Skidding Accidents. Tires, Vehicles, and Vehicle Components," Washington, D.C., 1977
p113-25
1977; 29refs
Presented at Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 364

HS-021 379

THE EFFECT OF OPERATING CONDITIONS ON THE SKID PERFORMANCE OF TIRES

A test program on the skid performance of tires considered effects of tire load, tire inflation pressure, road speed, and surface water depth by multiple regression computer analysis. An ASTM (American Society for Testing and Materials) type control tire and a production bias belted tire were used. Both peak and locked wheel coefficients of friction were measured using two skid trailers. All tests were run on a wet surface with either the skid trailer's onboard watering system spreading 0.51 mm of water on the test track or sprinklers flooding the track surface to a depth of 3.05 mm. The water film thickness used in the self-watering phase is typical of both tire testing and field service conditions. The flooded water depth is greater than that normally experienced on public roads. Load, speed, and inflation were varied over a range of three values. Two surfaces were used, SN 35 plus or minus 5 concrete and SN 60 plus or minus 5 asphalt, both typical of highway construction. Of the variables tested, load and inflation had the least effect on traction over the range through which they were varied. Speed and water depth interacted, causing a significant decrease in skid coefficients with an increase in both parameters. Asphalt was more sensitive than concrete to changes in all parameters. Speed was the dominant variable for both peak and slide when the surfaces were flooded. Correlation between the two tires was good.

by Steven R. Sacia
Goodyear Tire and Rubber Co.
Contract DOT-HS-205-2-238
Publ: HS-021 364 (TRR-621), "Skidding Accidents. Tires, Vehicles, and Vehicle Components," Washington, D.C., 1977
p126-35
1977; 9refs
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HS-021 380

INFLUENCE OF TREAD DEPTH ON WET SKID RESISTANCE OF TIRES

Bald tires have lower skid resistance than tires with full tread depth, and are more frequently involved in wet accidents. Studies made in The Netherlands, Germany, and the United Kingdom are reviewed. For car tires, the braking force coefficients (peak value and locked wheel value) as well as the side force coefficient are greatly influenced by tread depth of tires. However, road surface texture and vehicle speed are the most important factors. On road surfaces where water drainage is good, influence of tread depth on skidding potential is reduced. On smooth road surfaces tread grooves are the main drainage system; consequently a reduction in tread depth results in a drastic drop in braking force coefficients. Cross ply tires give lower braking force coefficient values compared to radial ply tires, due to different tread patterns. A legislative minimum tread depth of 1.6 mm is recommended for car and truck tires. Current requirements in various countries are charted. Skid resistance of truck tires is generally lower than for car tires. Influence of tread depth is similar, but the drop in skid resistance is more gradual. The drop in skid resistance depends not only on road surface texture depth and vehicle speed, but also on the micro roughness of the road surface.

The cross ply tire did not essentially differ in behavior from radial ply tires.

by Albert Dijks
Delft Univ. of Technology, The Netherlands
Publ: HS-021 364 (TRR-621), "Skidding Accidents. Tires, Vehicles, and Vehicle Components," Washington, D.C., 1977
p136-47
1977; 11refs
Presented at Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 364

HS-021 381

THE WET ROADHOLD OF TYRES [TIRES] - A EUROPEAN VIEWPOINT

It was within Europe that the initial concern for tire performance under wet conditions was isolated and related to the safety of the road transport system, and where many of the approaches towards the theoretical understanding of polymer friction and wear were initiated. Wet roadhold performance of car and truck tires has been approximately doubled over the last two decades through advances in tire construction and compounding technology; however this is usually accompanied by a predictable loss in wear resistance. This problem will be alleviated by production of steel breaker radial ply tires and a trend to lower aspect ratio tires. Research and numerous theories regarding rubber friction have not yet led to a full understanding of substrate friction properties. Optimum physical properties of tread compound for wet skidding resistance depend on the road surface characteristics and operating conditions of the tire. Under peak rolling conditions those polymers of inherently high friction produce their maximum values with lower loadings of carbon black compared with the locked wheel situation where particularly on surfaces of low drainage ability a high compound modulus minimizes the closure of the tread pattern elements and the breakdown of the pertaining lubrication condition. Road surface definitely has the greatest influence on the attainment of a 'safe' value of wet skidding resistance. Road surface also influences the generation of tire to road noise. Other aspects of road conditions, such as resistance to wheel tracking, will also affect not only water depths but vehicle stability under lane changing maneuvers. Roads and tires should not be considered separately from braking characteristics. European legislation for tire roadhold performance has been avoided to date, except for national specifications on minimum tread depth, usually 1.0 mm.

by A. R. Williams
Dunlop Ltd.
Publ: HS-021 364 (TRR-621), "Skidding Accidents. Tires, Vehicles, and Vehicle Components," Washington, D.C., 1977
p148-61
1977; 39refs
Presented at Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 364

HS-021 382

EMERGENCY AND HIGH SPEED DRIVING TECHNIQUES

A manual on emergency driving techniques presents data and guidelines on driving emergency or pursuit vehicles at the "limits of adhesion," based on data as to what initiates loss of control in a high speed evasive driving maneuver. High speed emergency driving involves two closed loop systems: the vehicle and the driver, and the vehicle, driver, and the environment. The former involves steering and braking maneuvers, vehicle response, and further maneuvers. The latter system incorporates such environmental dangers as vehicles or obstacles in the road ahead, or reckless drivers overtaking the emergency vehicle. Rolling contact with the road surface must be maintained so the driver can steer, and brake, to control his vehicle. Steering characteristics of tires, forces affecting vehicle control, and cornering techniques must be mastered for driving safety. Forces affecting vehicle control in a constant radius turn include steering angle of front tires, vehicle drift angle, instantaneous direction of travel and speed of vehicle, weight of vehicle at its center of gravity, and the centrifugal force which incorporates velocity, acceleration of gravity, and radius of the circular path. Other factors to be considered in cornering include cornering force, drag force, side force, self-aligning torque, and pneumatic trail. The coefficient of friction of a given road surface must also be considered. Mastery of braking includes understanding of brake fade, characteristics of disc brakes, the relationship between friction coefficients and stopping distance, and the influence of a given individual's reaction time. Tire design characteristics discussed include adhesion ability of various tire types as well as cornering force, steering response, rolling resistance, increased tire mileage, tire ripple, tire inflation, understeer, neutral steer, oversteer, and tire hydroplaning. The driver of an emergency vehicle needs to expect the unexpected, such as having to choose an escape route in a potential collision situation. The position of the driver's body, hands, and feet are important, as well as his physical condition and avoidance of the effects of alcohol, prescription drugs, marihuana, fatigue, and uncorrected vision defects. Restraint systems should always be worn; possible cardiovascular, rib, and skull damage to an unrestrained driver in a crash is illustrated. Factors that the high speed pursuit driver should take into account include the effects of tunnel vision and the adrenalin kick characteristic of high speed driving, as well as the danger of blowouts and the need for good anticipation and finesse. The driver of an emergency vehicle should be capable of performing basic maintenance checks, and should do so regularly.

by John M. Clark, Jr.
1976; 137*p*
Availability: Gulf Publishing Co., Book Div., Houston, Tex.

HS-021 383

SKIDDING ACCIDENTS. WET-WEATHER ACCIDENT EXPERIENCE, HUMAN FACTORS, AND LEGAL ASPECTS

Ten research papers from the U.S. and from European countries detail recent research studies and regulations concerning set pavement skidding accidents. Friction numbers alone, as measured under standardized conditions of test, cannot be expected to give a clear-cut ranking to surfaces according to their safety for traffic under wet conditions. A statistical relation is sought between skidding resistance of road surfaces and relative road risks. Recent research in Great Britain has shown that for asphalt surfaced roads the sideways force coefficient can be predicted from a knowledge of the stone used in surfacing, traffic intensity, and amount of maneuvering. Both urban and rural state trunkline intersections are examined with regard to their wet accident percentages. A state of the art overview of the human factor in skid accident causation and

prevention summarizes relevant literature on the driver and skid potential, in terms of traffic control devices as skid accident countermeasures. Legal implications of regulations aimed at reducing wet-weather skidding accidents are analyzed, for example, state liability. A conceptual methodology has been formulated to establish cost-effective frictional requirements. A computerized benefit/cost model can be used to evaluate alternative accident reduction measures Grooving in road pavements has proven effective in skidding accident reduction in Switzerland. Brake antilock systems, though not commerically successful at this time, seem to be economically justified for private passenger cars.

National Acad. of Sciences, Transportation Res. Board, 2101 Constitution Ave., N.W., Washington, D.C. 20418
Rept. No. TRR-623; 1977; 94p refs
Proceedings of the Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977. Abstracts in French and German.
Availability: Corporate author $3.60

HS-021 384

SKIDDING ACCIDENTS, FRICTION NUMBERS, AND THE LEGAL ASPECTS INVOLVED. REPORT OF THE PIARC TECHNICAL COMMITTEE ON SLIPPERINESS AND EVENNESS

Friction numbers alone, as measured under standardized conditions of test, cannot be expected to give a clear-cut ranking to surfaces according to their safety for traffic under wet conditions; this is due to the fact that various other factors affect skidding accidents. Nevertheless, the concept of standardized test conditions is inevitable from a practical point of view. Standard, guide, or minimum values of skid resistance should be formulated to serve as an acceptance criterion if the road construction work specifications include skid-resistance properties, and to assist highway authorities in making decisions on maintenance or renewal work. Regression type analyses have been used to compare accident figures or rates with friction numbers in The Netherlands, Germany, and France. The most striking evidence of the important role slipperiness can play in wet-road accidents is yielded, however, by reliable before-and-after studies done in Italy and Great Britain. Establishment of standard friction numbers is usually based on regression type analyses. From country to country such values are quite different in character and significance. They support highway authorities in decisions on maintenance and renewal work but only in Belgium, The Netherlands, and Switzerland do they serve as an acceptance criterion for road work. Two approaches for detecting road sections with insufficient friction levels are systematic routine measuring campaigns and evaluations of accident statistics, the latter preferably based on the proportion of wet-road accidents. Black spots in wet conditions can be successfully detected by calculating for each section of road under consideration the "proportion of wet-road accidents" to be compared with what is to be regarded as "normal" from a statistical point of view. Interdisciplinary work is necessary to elaborate proposals for remedial measures which will generally include factors other than slipperiness, for example, Safety Operation No. 6 in France. Legal or juridical aspects of skidding include the contractor's liability, the liability of the administration, and the liability of the civil servants. Regulations for which the contractor is held responsible include those dealing with specifications for road construction work. The highway administration may be liable for the standards it has set and for maintenance and roadway markings indicating potential skid areas. Liability of the civil servant or road engineer would probably involve a flagrant, even criminal, offense.

by K. H. Schulze; A. Gerbaldi; J. Chavet
Technische Universitat Berlin, Berlin, Germany; Ecole Nationale des Ponts et Chaussees, Paris, France; Administration des Routes, Bruxelles, Belgium
Publ: HS-021 383 (TRR-623), "Skidding Accidents. Wet-Weather Accident Experience, Human Factors, and Legal Aspects," Washington, D.C., 1977 p1-10
1977; 20refs
Presented at Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 383

HS-021 385

TRAFFIC ACCIDENTS AND ROAD SURFACE SKIDDING RESISTANCE

A statistical relation is sought between skidding resistance of road surfaces and relative road risks. Regarding the concept of accident quotient, the number of accidents occurring on a certain section of road within a certain period of time is related to the total number of kilometers traveled on that section in the period concerned. The involvement quotient is the number of vehicles, per million vehicle-kilometers traveled, subdivided into the categories passenger cars and goods vehicles, involved in an accident on a certain road surface. In order to eliminate influences other than skidding resistance, a distinction has been drawn between two types of road. Type 1 comprises roads with dual carriageways. Type 2, which is a more discontinuous type, comprises all the other roads. Accident data (60,000 accidents) were based on records kept by the police. Vehicle-kilometers have been calculated only in so far as they were traveled during rainfall or, alternatively, when no rain was falling. The accidents which occurred on a wet road surface, but not during rainfall, are assigned both to the skidding resistance class of the wet road and to the class of dry road surfaces. Each lower skidding resistance class is associated with a higher accident quotient. On the evidence of the statistical relation that has been found the highest possible skidding resistance is to be recommended for both types of road.

by Leonard H. M. Schlosser
Institute for Rd. Safety Res. SWOV, Voorburg, The Netherlands
Publ: HS-021 383 (TRR-623), "Skidding Accidents. Wet-Weather Accident Experience, Human Factors, and Legal Aspects," Washington, D.C., 1977 p11-20
1977
Presented at Second Annual Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 383

HS-021 386

THE LOCATION AND TREATMENT OF URBAN SKIDDING HAZARD SITES

Recent research in Great Britain has shown that for asphalt surfaced roads the sideway force coefficient (skidding resistance) can be predicted from a knowledge of the stone used in surfacing, traffic intensity, and amount of maneuvering (i.e. braking, turning, or accelerating, as in intersections). About 70% of all road accidents occurring in Great Britain are in urban areas. In London, about 70% of all accidents occur on

treatment may not be economically justifiable. In London, improvements have been aimed at the road junction problem. More than 800 junction and other similar hazard areas (such as approaches to pedestrian crossings) have been treated with an epoxy resin/calcined bauxite form of surface dressing. Accidents at treated sites have been reduced by 31%, or 2500 per year. Economically this form of treatment is feasible; an expenditure of 3 million pounds over a ten year period is estimated to produce a saving in accident costs of at least 24 million pounds in 1970 values. Site locations favorable to accident rate reduction by surface treatments can be identified with a machine which monitors skid resistance along with computerized accident data. Localized treatment of city road junctions could be a successful method of accident reduction in many major cities.

by Leslie W. Hatherly; Arthur E. Young
Greater London Council, England
Publ: HS-021 383 (TRR-623), "Skidding Accidents, Wet-Weather Accident Experience, Human Factors, and Legal Aspects," Washington, D.C., 1977 p21-8
1977; 14refs
Presented at Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 383

HS-021 387

PREDICTION OF WET SURFACE INTERSECTION ACCIDENTS FROM WEATHER AND SKID TEST DATA

Both urban and rural state trunkline intersections are examined with regard to their wet accident percentages. The examination first takes account of the estimated percentage of highway surface wet time for each month. Because precipitation data are available only for designated time intervals, a method is developed to convert these data into percent wet time, which is a factor necessary in assessing wet surface exposure at intersections. Using this conversion method the precipitation data from 120 of Michigan's weather stations are transformed to give a month by month wetness profile for the entire state for the years 1963 to 1974. The range in monthly wetness for this period is from less than 1% to more than 25%. This potential 25 to 1 ratio is very influential in wet accident incidence and should be taken into account before other variables are examined. Nearly 40,000 accidents occurring at over 2000 intersection locations for which a skid coefficient value was available were tabulated to provide wet accident percentages. These data together with the location's wet time percentage, as estimated from the nearest weather station, provide an opportunity to statistically fit a wet accident model for the variables included. The fit is satisfactory and suggests an accelerating function for skid coefficient. For all levels of wetness, a skid coefficient less than about 30 is accompanied by an accelerating increase in wet accident percentages; although the actual shape of the curve depends on wet time. The model

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1977; 10refs
Presented at Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 383

HS-021 388

HUMAN FACTORS IN SKIDDING: CAUSATION AND PREVENTION

A state of the art overview of the human factor in skid accident causation and prevention summarizes relevant literature on the driver and skid potential, in terms of traffic control devices as skid accident countermeasures. Literature on driver and skid potential relates to accident causation by describing what is known in terms of driver perceptions and responses during driving conditions characterized by skid accident potential. The second body of literature, countermeasure considerations, deals with prevention in terms of a review of candidate traffic control devices as potential remediation techniques. The detection and appreciation of hazardous situations during wet weather conditions tends to come from knowledge of the fact that it is raining, the pavement appearing wet, or changing road alignment (as on horizontal curves). Communicating potential hazards to motorists through static signing is generally ineffective; whereas flashing signals, dynamic displays, and advisory speeds at such highway sites are effective in modifying control behavior and presumably in the reduction of loss of control. Specific road geometries can lead to higher than acceptable frictional demands because their difficulty in negotiation in underestimated by motorists. An immediately implementable countermeasure is activated advisory speed signing at curve locations, which would automatically flash to identify hazard when the road is wet. A systematic human factors analysis of the driving task in a potential skid hazard environment is necessary to examine broadly based causes of skidding accidents.

by Fred R. Hanscom
BioTechnology, Inc.
Publ: HS-021 383 (TRR-623), "Skidding Accidents, Wet-Weather Accident Experience, Human Factors, and Legal Aspects," Washington, D.C., 1977 p40-7
1977; 35refs
Presented at Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 383

HS-021 389

LEGAL IMPLICATIONS OF REGULATIONS AIMED AT REDUCING WET-WEATHER SKIDDING ACCIDENTS ON HIGHWAYS

The following regulations for reducing wet-weather skidding accidents are analyzed as to their legal implications: possible uniform minimum standards for pavement design, mix and selection, for resurfacing or grooving and for warning signs; accident data collection; and establishment of priorities for highway rehabilitation and repair. Specific areas of state action

decisions in many states, state highway departments are more vulnerable to tort suits. A number of states have enacted tort claims legislation setting forth procedures for filing negligence actions against government agencies; this may imply a duty on the part of the state highway department to guard against, or give adequate warning of, slippery road conditions. Skid reduction regulations are usually admissible into evidence and usable at trial. Reference is made to Federal and state statutes, case law, articles, and in particular, to Federal Hwy. Administration skid reduction program regulations.

by Larry W. Thomas
Transportation Res. Board
Publ: HS-021 383 (TRR-623), "Skidding Accidents, Wet-Weather Accident Experience, Human Factors, and Legal Aspects," Washington, D.C., 1977 p48-50
1977
Presented at Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 383

HS-021 390

METHODOLOGY FOR ESTABLISHING FRICTIONAL REQUIREMENTS

A conceptual methodology formulated to establish cost-effective frictional requirements is based on the calculations of a margin of safety (MOS) defined as the difference between available tire/pavement friction and the level of driver demand for friction. A review of literature on skidding accidents suggests that determination of tire/pavement frictional levels is highly dependent on site specific considerations including the environment, traffic operational characteristics, and vehicle maneuver determining roadway geometry. Models are constructed to calculate the level of available tire/pavement friction and the level of frictional demand. To test the methodology, data were collected at four two-lane passing sites in order to characterize the relationship between combinations of lateral and longitudinal acceleration traffic parameters and site variables. Experiments employed an impeding vehicle to encourage selected drivers to perform a passing maneuver. A model was developed to predict expected frequency of passes on a two-lane rural road as a function of traffic distribution, speed, and driver behavioral characteristics. The problem of relating combinations of longitudinal and lateral accelerations developed by a vehicle to resultant vehicle acceleration and pavement skid number, including effects of vehicle dynamics, vehicle configuration, and tire properties, remains unsolved. Detailed application of the proposed methodology requires development of continuous frictional relationships between variables, which have not yet been developed.

by Joel M. Zuieback
Science Applications, Inc., El Segundo, Calif. 90245
Publ: HS-021 383 (TRR-623), "Skidding Accidents, Wet-Weather Accident Experience, Human Factors, and Legal Aspects," Washington, D.C., 1977 p51-61
1977; 20refs
Presented at Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 383

A computerized benefit/cost model developed for the Federal Hwy. Administration (FHWA) can be used to evaluate alternative accident reduction measures. The model was designed for use by state highway departments and is capable of evaluating both countermeasures that increase frictional supply and countermeasures that reduce frictional demand. Model logic is applicable to year-end cash flows, which are typically used for highway analyses. For comparative purposes, all costs and benefits are expressed as equivalent uniform annual cash flows. The interest rate used to convert one-time costs to equivalent uniform annual costs can be selected by the user. Emphasis is placed on compatibility with typical highway department practices and the capability to provide fair comparisons, in an economic sense, between alternative countermeasures. The model incorporates relationships between skid number and accident rate obtained from an extensive data collection and analysis phase. The effects on accident rate of factors other than skid number are based on the literature. A tested version of the computer program should be available from the FHWA in the near future. The model is being programmed in Fortran IV and is adaptable to a large number of computer systems being operated in the U.S. and elsewhere.

by A. D. St. John; D. W. Harwood; R. R. Blackburn
Midwest Res. Inst.
Publ: HS-021 383 (TRR-623), "Skidding Accidents, Wet-Weather Accident Experience, Human Factors, and Legal Aspects," Washington, D.C., 1977 p62-9
1977; 10refs
Presented at Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 383

HS-021 392

THE INFLUENCE OF GROOVING OF ROAD PAVEMENTS ON ACCIDENT FREQUENCY

Frequency of accidents and the percentage of accidents on wet and dry road surface for the years 1966 to 1973 have been analyzed on a stretch of road 44 km long with a few very smooth spots on a portion about 2 km long. Data for analyses were provided by official traffic counts, precipitation measurements of the Swiss Central Meteorological Agency, and accident reports of highway police. The 2 km long smooth sections have been grooved twice during the observation period with groove distances of 5.0 and 2.0 m. Relative values of accident frequency per km and 1 million vehicles were determined in relation to the number of wet and dry days of each year, for the grooved and ungrooved sections. The percentage of accidents on wet surface compared to the total number completes the study. Results show clearly a positive influence of grooving, even with great groove distances, and the effect of a reduction of the water film on skidding properties. Grooves have a favorable influence on surface drainage if they are cut at such an angle to the line of maximum slope, that water reaches the next grooves after a very short drainage distance. Any further improved adhesion will however only be reached when grooves at a very narrow distance create an additional keeing reaction. Suitable measures for better skidding conditions on the total length of 44 km would be advantageous. Savings from accident avoidance are estimated at about 3 million Swiss francs in five years for 58 accidents.

Liability for wet pavement skidding accidents varies; reasonableness of the public's actions generally will be the deciding factor on whether liability will ensue.

by E. Zipkes
Federal Inst. of Tech., Zurich, Switzerland
Publ: HS-021 383 (TRR-623), "Skidding Accidents, Wet-Weather Accident Experience, Human Factors, and Legal Aspects," Washington, D.C., 1977 p70-5
1977; 8refs
Presented at Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 383

HS-021 393

EFFECTIVENESS OF ANTILOCK BRAKES IN PASSENGER CARS

Brake antilock systems have been developed and tested extensively in passenger cars over the past 20 years. Although both two-wheel and four-wheel systems perform very well under treacherous driving conditions, they have not proved to be commercially successful. Published studies indicate that antilock braking in automobiles has worthwhile potential for skid control and accident avoidance. An economic study of 100 skidding accidents from a randomly selected sample of 613 insurance cases shows that the present value of the lifetime savings of a two-wheel antilock brake system assumed to be sold in 1976 is estimated to be about $95 and for a four-wheel system to be approximately $180. The benefit/cost ratios are 1.4 for a two-wheel and 1.3 for four-wheel antilock brake systems. Indicated payback periods are about seven years for a two-wheel system and eight years for four-wheel antilock braking. Antilock braking systems seem to be economically justified for private passenger cars, particularly for high-mileage and high speed driving. Motivation to purchase antilock systems would be enhanced if the payback period could be reduced to three or four years of car ownership.

by Nathaniel H. Pulling
Liberty Mutual Insurance Co.
Publ: HS-021 383 (TRR-623), "Skidding Accidents, Wet-Weather Accident Experience, Human Factors, and Legal Aspects," Washington, D.C., 1977 p76-9
1977; 20refs
Presented at Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
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HS-021 394

SKIDDING ACCIDENTS. ANCILLARY PAPERS

Sixteen papers are compiled which were submitted but not included in the conference program of a forum for international exchange of information on all aspects of wet weather skidding accidents on highways. Six brake antilock systems are evaluated as to their suitability for various vehicle types. A study was made concerning contact between a tire and road surface, conducted by means of an experimental multifactor investigation. A texture profile measuring device is used to confirm the influence of microtexture and macrotexture on skid resistance in wet conditions. Friction coefficients and water film thickness are evaluated regarding rapid decrease in friction leading to aquaplaning. Microtextural and macrotextural requirements for skid resistance vary depending on use requirements for roads or airfields. Skid resistance treatments based on epoxy resin binders and calcined bauxite have proved highly effective; the same compound with bitumen is cost-effective in reducing wet road skidding accidents. A study of various skid resistant pavements was undertaken in France in preparation for resurfacing cement highways. Chipped bituminous concrete is durable and displays high evenness as a highway construction material. Chipping of fresh cement concrete pavements during the laying process provides a coarse macrotexture, providing a high degree of skid resistance. Runway slipperiness research since 1968 has focused on flooding, hydroplaning, slipperiness identification, and rubber deposit removal. Two statistical methods have been developed to identify sections of highway that could be suspected of having a deficient wet pavement skid resistance. Wet accident experience of four rural highway sections has been related to measurements of average wet pavement skid resistance in separate analyses. Accident data in New Zealand are analyzed in order to establish types of accidents occurring which are most likely to involve skidding. A relationship is established between accident rate and skid number for various combinations of highway type, area type, and traffic volume. Conspicuous signing is effective in reducing motorists' speed on curves during wet pavement conditions.

National Acad. of Sciences, Transportation Res. Board, 2101 Constitution Ave., N.W., Washington, D.C. 20418
Rept. No. TRR-624; 1977; 157p refs
Papers ancillary to the Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: Corporate author $6.40

HS-021 395

DEVELOPMENT AND EVALUATION OF ANTI-LOCK BRAKE SYSTEMS

Six two-wheel, four-wheel, and articulated vehicle antilock systems of various configurations are evaluated, as well as techniques for evaluating performance of antilock systems, including straight-line braking, use of a split coefficient surface, and braking in a turn. The best antilock system configuration for a vehicle class requires a trade-off among vehicle design factors, desired level of braking, vehicle handling performance, and cost. A rear-axle system on a two-axle vehicle prevents spinout under most normal braking conditions, and provides a shorter stop than locked wheel or driver-best-effort. A four-wheel system generally provides even shorter stops, while allowing the driver to steer the vehicle around hazards during panic stops. Individual wheel control offers shorter stops with some sacrifice in vehicle stability. Most antilock systems on passenger cars are either two wheel rear-axle control or rear-axle control with prop shaft sensor, both of which can be installed at minimal cost. Highway tractors usually have antilock systems of a four-wheel type, with front and rear axle control. Braking in a turn or on a surface with large side-to-side coefficient differences is probably the best test of antilock system performance. Four-wheel simulation studies have been conducted on a hybrid computer to evaluate braking performance with locked wheels compared to that achievable

Rothfusz
Bendix Res. Labs.; Bendix Automotive Control Systems Group; Bendix Heavy Vehicle Systems Group
Publ: HS-021 394 (TRR-624), "Skidding Accidents. Ancillary Papers," Washington, D.C., 1977 p1-14
1977; 7refs
Ancillary to Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 394

HS-021 396

TYRES [TIRES] AND ROAD SURFACES

A study of the contact between a tire and a road surface was conducted by means of an experimental multifactor investigation. It was attempted to determine not only the effects of variables such as type of road surface and speed on the skid resistance, but also interaction effects. In the first phase the first-order and second-order factors were separated; the second phase served to determine the numerical influence of the road surface characteristics and the speed on the size of the brake and sideway forces. It was found possible to compile a mathematical relation incorporating the contribution of the macroroughness and microroughness of the road surface and also of the speed to the brake and sideway forces. In the third phase a similar mathematical relation was drawn up for truck tires. Car and truck tires were compared by reference to results. A main feature is that with truck tires the values of the available brake forces are about a factor two lower than with car tires. Among the characteristics of the road surface, the microroughness has mostly considerable influence on skid resistance. The influence of macroroughness of the road surface counts heavily almost exclusively at high speeds. Recommendations for official measures emphasize standards to be met by the microroughness and macroroughness of road surfaces.

by Leonard H. M. Schlosser
Institute for Rd. Safety Res. SWOV, Voorburg, The Netherlands
Publ: HS-021 394 (TRR-624), "Skidding Accidents. Ancillary Papers," Washington, D.C., 1977 p15-26
1977; 14refs
Ancillary to Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 394

HS-021 397

ROAD SURFACE CHARACTERISTICS AND HYDROPLANING

The influence of microtexture and macrotexture on skid resistance in wet conditions is confirmed using measuring devices such as a texture profile measuring device which allows quantification and qualification of macrotexture. Microtexture is chiefly connected with friction force developed both for dry and wet pavements. Macrotexture makes it possible to squeeze out quickly the water lying on the road surface, and at the same time reduces waterfilm lying on the surface. A relationship between surface texture values and the thickness of waterfilm for hydroplaning conditions of a certain speed has been found after numerous skid resistance studies on standard measurement conditions (waterfilm up to 1.0 mm). Results indicate that microtexture is important for level of curves, which also affects curve inclination. On pavement surfaces without sharpness even a very good macrotexture cannot improve the friction ratio. Classification of pavement surfaces based on standard measurements with a waterfilm of 0.5 mm is correct for speeds up to 60 km/h and for thicker waterfilms (up to 10 mm). For speeds greater than 60 km/h the friction coefficient is distinctly influenced by waterfilm thickness. Macrotexture, tire mold, and load gain in importance. Waterfilm should not be greater than 3.0 mm on a pavement having a friction coefficient of about 0.7 and a texture of about 0.4 in order to be safe at speeds of about 100 kmh.

by Rita Pelloli
Federal Inst. of Tech., Zurich, Switzerland
Publ: HS-021 394 (TRR-624), "Skidding Accidents. Ancillary Papers," Washington, D.C., 1977 p27-32
1977; 6refs
Ancillary to Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
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HS-021 398

SKID RESISTANCE AND WATER FILM THICKNESS

A device used to measure water film thickness and its evolution over time is based on the principle of rapid neutron deceleration by hydrogen nuclei. This method allows a "point" measurement with respect to the whole pavement, and makes it possible to obtain a mean water film thickness which accounts for pavement asperities. The instrument can measure water film thicknesses of zero to 8.0 mm plus or minus 0.1 mm. Data of output surfaces function are obtained on a miniature runoff simulation computer model in the laboratory; the geometrical data are measured on the road. A car with a gyroscopic machine gives the gradient and the ruled surfaces of pavement (scale of lie) treatment gives an automatic method to find water accumulation zones.

by R. Laganier
Laboratoire Central des Ponts et Chaussees, Groupe Glissance, Paris, France
Publ: HS-021 394 (TRR-624), "Skidding Accidents. Ancillary Papers," Washington, D.C., 1977 p33-9
1977; 11refs
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HS-021 399

THE DESIGN AND PERFORMANCE OF HIGH FRICTION DENSE ASPHALTS

Concepts of the most desirable microtexture and the most appropriate macrotexture of road and airfield surfaces have been combined into a rational method of aggregate grading design, in order to develop a range of road surfacing materials with good skid resistance properties over the range of traffic speeds and other hydraulic conditions for which they are designed. Skid resistant asphalt surfacings can be designed according to a method based on studies of fundamental packing properties

skid resistance, equally necessary properties of resistance to deformation in wheel tracks, durability, and low noise generation. Results are presented concerning some of the approximately 100 sites so far surfaced with wearing course materials designed according to these principles, in order to show their generally satisfactory nature. Mixes produced according to the proposed method improve other forms of road/tire interaction beyond skid resistance, for example, noise generation, riding comfort, and rolling resistance.

by Geoffrey Lees; Izz ed Din Katekhda; Robert Bond; A. Roger Williams
University of Birmingham, England; Jouzy and Partners, Dubai, Oman; Dunlop Ltd., England
Publ: HS-021 394 (TRR-624), "Skidding Accidents. Ancillary Papers," Washington, D.C., 1977 p40-51
1977; 37refs
Ancillary to Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 394

HS-021 400

SOME U.K. [UNITED KINGDOM] DEVELOPMENTS IN SKID-RESISTANT ROAD SURFACINGS

Various types of skid-resistant treatment have been developed for different categories of road. For particularly critical areas such as junctions in cities, treatments based on epoxy resin binders and calcined bauxite have proved highly effective in maintaining skid resistance and reducing accidents. This combination was first proposed by the British Rd. Res. Lab. in 1959 and such treatments have been in commercial use in the United Kingdom and several other countries for up to nine years. The Shellgrip binder most commonly used in this type of work is a two-component bitumen-extended epoxy resin compound. Equal parts of the two components are thoroughly mixed together and spread or sprayed on the road surface, preferably by machine, at a minimum rate of 1.35 kg per sq m. The binder is then covered with an excess of small calcined bauxite chippings and the treatment is allowed to cure, after which excess aggregate is removed and the road opened to traffic. For heavily trafficked but less critical roads, various improved methods of conventional bituminous surface dressing are used, the most promising systems being based on the use of high-viscosity cutback with precoated chippings and a polymer/bitumen emulsion with hot chippings. Methods of adapting open textured asphalt carpets or friction courses (already well proven on airfield runways) to heavily trafficked roads and city streets have been considered. Bauxite slurry seals, an alternative treatment, are potentially good for wider applications: however, suitable specifications for differing traffic patterns need to be developed.

by D. R. Lamb
Shell International Petroleum Co. Ltd.
Publ: HS-021 394 (TRR-624), "Skidding Accidents. Ancillary Papers," Washington, D.C., 1977 p52-62
1977; 16refs
Ancillary to Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 394

antiskid surfacing has been demonstrated to be cost effectiv in reducing wet road skidding accidents. Over one millio square meters of this type of surfacing have now been lai throughout the world. The excellent performance of the trea ment results from the use of calcined bauxite aggregate, hav ing high resistance to polishing and abrasion, bonded firmly t the road surface with a thermosetting resin, which preven rolling or embedment. From the contractor's point of view th material needs to be laid under carefully controlled conditio achieved by the use of machinery designed to give precise pr portioning and distribution of the components. The two-com ponent applicator machine blends the calcined bauxite ar epoxy resin binder and sprays the mixture evenly over th road. Binder components are heated for application to 50° The process has the advantage of fast application and does n require modification to existing markings or street furnitur With careful planning the contract can be carried out wi minimum disruption to traffic flow. Different techniques a needed to achieve optimum adhesion to varying substrat (asphalt, concrete, or steel). Different types of traffic situ tions which can be successfully treated include junctior pedestrian crossings, bridges, tunnels, and rumble areas.

by P. B. Poulson; J. F. Wood
Prismo Universal Ltd.
Publ: HS-021 394 (TRR-624), "Skidding Accidents. Ancillary Papers," Washington, D.C., 1977 p63-71
1977; 10refs
Ancillary to Second International Skid Prevention Conferenc Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 394

HS-021 402

REHABILITATION OF CONCRETE PAVEMENTS ANTI-SKID PROPERTIES

A study of various methods of skid resistance improveme was undertaken in preparation for resurfacing ceme highways built in France between 1960 and 1970, whi presently have low friction coefficients due to inefficient bu lap surface treatment. Some 25 experimental stretches highways have been made, including transversal (diamo sawing and percussion) and longitudinal (diamond sawi grooving with different grooving patterns, and surfa dressings. For longitudinal grooving, narrow and closely- grooves are more efficient than wide and far apart groov Regarding braking force coefficient, longitudinal groov leads to surfacings equivalent to a poor asphaltic concrete; sideways force coefficient, however, is not much more ef cient. The influence of groove depth is not great, provic depth is more than 2 mm. For the same quantity of concr removed by grooving, the braking force coefficients obtair with longitudinal and transversal grooving are the same, the sideways force coefficient is much higher with longitudi grooving. It is possible to use surface dressings on a hig trafficked concrete motorway (40,000 vehicles per day) w hard stone chippings and a polymer modified asphaltic bind This process is cheaper than grooving on concretes made w

Publ: HS-021 394 (TRR-624), "Skidding Accidents. Ancillary Papers," Washington, D.C., 1977 p72-81
1977; 7refs
Ancillary to Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 394
1977; 20refs
Ancillary to Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 394

HS-021 404

ACTUAL EXPERIENCE REGARDING THE CHIPPING OF CEMENT CONCRETE

Chipping of fresh cement concrete pavements is a technique for creating, during the laying process, a coarse macrotexture indispensable for obtaining a high degree of skid resistance, even at high speed, on wet pavements. Background experimentation centered on characteristics of the technique (composition of the concrete, and stones to be used in the chipping), and the performances achieved with regard to skid resistance and durability; and also on conception and development of an operational chipping machine. The chipping technique comprises two phases: first, uniform distribution of chipping stones, sized 14-20 mm and highly resistant to polishing, over the concrete surface, previously compacted and profiled, in the proportion of 6 to 8 kg/sq m. The second phase involves insertion of the chippings into fresh concrete by tamping with vibration. In addition to its safety advantages, the chipping process permits the use of polishable aggregates in the concrete mass without reducing skid resistance, the contact surface between the pavement and the tread of tires being constituted by slightly polishable chipping stones. It is possible to obtain economically a high degree of skid resistance in certain dangerous places or on roads with heavy traffic, given the small quantity of chippings of high polished stone value used. Long-term maintenance of the pavement's nonskid qualities results from durability of the microtexture and macrotexture.

by F. Fuchs
Centre de Recherches Routieres, Bruxelles, Belgium
Publ: HS-021 394 (TRR-624), "Skidding Accidents. Ancillary Papers," Washington, D.C., 1977 p90-4
1977; 10refs
Ancillary to Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 394

HS-021 405

STATUS OF RUNWAY SLIPPERINESS RESEARCH

Runway slipperiness research performed in the U.S. and Europe since 1968 has focused on flooding, hydroplaning, slipperiness identification, and runway rubber deposits, with the purpose of combatting problems relative to aircraft operations on slippery runways. Prediction is possible of the rainfall intensity required to initiate flooding in aircraft tire paths. A pavement must be provided with good cross slope and surface texture to minimize risk of flooding and dynamic hydroplaning at take-off and landing during rainstorms. Surface winds can wheel spin-up speed; water pressure propagation under the footprint; influence of macrotexture and microtexture; effects of tires and their operating modes; and prediction of tire braking and cornering characteristics on wet runways. Slippery runway identification has required development of ground/vehicle friction measuring techniques and equipment. Development has focused on ground/vehicle to ground/vehicle and aircraft to ground/vehicle correlations. Measurements currently in use are the standard U.S. Air Force runway skid resistant tests, and the Federal Aviation Administration's suggestions in its advisory circular No. 150/5320-12. Antihydroplaning runway surface treatments have included grooving, porous friction courses, and removal of rubber deposits, especially from ungrooved runways.

by Walter B. Horne
National Aeronautics and Space Administration, Langley Res. Center
Publ: HS-021 394 (TRR-624), "Skidding Accidents. Ancillary Papers," Washington, D.C., 1977 p95-121
1977; 42refs
Ancillary to Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 394

HS-021 406

TWO STATISTICAL METHODS FOR DETECTION OF 'SLIPPERY WHEN WET' HIGHWAY SECTIONS

Two statistical methods have been developed to identify sections of highway that could be suspected of having a deficient wet pavement skid resistance. The Quality Control Chart Method and Significant Relative Frequency Method were applied to sections of highway, total length 528 km, using annual "raw" accident experience for each year of the period 1969 to 1975 inclusive. The basis of both methods is the New Brunswick accident report form which may be considered similar to most report forms used in North America. In New Brunswick, the wet pavement accident event is identified by the indication of both a "wet" and a "wet-slippery" road surface condition, and an indication of whether or not one or more vehicles were "skidding or swerving" prior to the accident event. The quality control chart method utilizes past "raw" accident experience of a highway section to predict expected accident experience for any given time period. Actual experience is compared with that predicted and statistical results are given to enable a decision to be made with respect to whether or not the accident experience worsened, remained the same, or improved. The significant relative frequency method utilizes the ratio of the number of a particular class of accident event to the total number of accidents occurring along a section of highway. This ratio, the relative frequency, is given statistical significance and is transformed to a significant relative frequency. The significant relative frequency of wet pavement accidents of a highway section is compared to an acceptable minimum relative frequency. Sections of highway identified by analyses using these methods were tested to determine their average wet pavement skid resistance. Comparison of observed average skid resistance measurements with recommended minimum skid resistance levels for highways having mean speeds in the range of 64 to 112 km/hr indicated that

1977; 8refs
Ancillary to Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 394

HS-021 407

THE RELATIONSHIP BETWEEN ACCIDENT EXPERIENCE AND WET PAVEMENT SKID RESISTANCE

Wet accident experience of rural highway sections in New Brunswick, Saskatchewan, Ontario, and Kentucky has been related to measurements of average wet pavement skid resistance in separate analyses. Two classes of highway were analyzed: two-lane undivided rural arterials having posted speeds of 96 to 104 km/h and average annual traffic volumes of up to 8400 vehicles per day; and two-lane divided rural freeways and parkways having posted speeds 112 km/h and average annual traffic volumes of 1100 to 34000 vehicles per day. The data exhibited strong nonlinear variation and considerable scatter. Ten point moving average plots of wet accident experience versus measurements of average wet pavement skid resistance served to subdue scatter and identify those levels at which significant increases in wet pavement accident experience occurred. Plots of wet accidents per mile versus average wet pavement skid resistance appeared to have less scatter than those in which the significant relative frequency of wet accidents was used as the wet accident variable. In addition, wet accident experience averaged over two or more years shows less scatter than plots of yearly wet accident experience. Preliminary equations have been developed from the data using a nonlinear least squares computer program. Two-lane undivided rural highway data exhibit a higher level of wet pavement skid resistance demand than that for four-lane divided rural highways. Wet pavement skid resistance ranges at which marked increases in wet accident experience occurred were, for two-lane rural arterials, pavement skid resistance 55-60; for four-lane rural freeways and parkways, 43-50. Present recommended minimum wet pavement skid resistance levels for highways having mean speeds in the range of 64 to 112 km/h appear to be low when the trends of this study are examined.

by J. Paul Dean
University of New Brunswick
Publ: HS-021 394 (TRR-624), "Skidding Accidents. Ancillary Papers," Washington, D.C., 1977 p129-35
1977; 8refs
Ancillary to Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 394

HS-021 408

WET WEATHER INJURY ACCIDENTS ON NEW ZEALAND ROADS

Accident data for 1973 in New Zealand have been analyzed in order to establish the types of accidents occurring which are most likely to involve skidding, and to evaluate associated factires. Collisions with obstructions, rear end collisions, and hitting pedestrians were overrepresented at night during wet weather but not during daytime wet weather.

by C. M. Clissold
Ministry of Transport, New Zealand
Publ: HS-021 394 (TRR-624), "Skidding Accidents. Ancillary Papers," Washington, D.C., 1977 p136-40
1977; 1ref
Ancillary to Second International Skid Prevention Conference Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 394

HS-021 409

EVALUATION OF ACCIDENT RATE-SKID NUMBER RELATIONSHIPS FOR A NATIONWIDE SAMPLE OF HIGHWAY SECTIONS

A relationship can be established between accident rate and skid number for various combinations of highway type, area type (urban/rural), and traffic volume. Accident rate, skid number, and related data were collected for two one-year periods on 428 highway sections located in 16 states. Statistical analysis of data was conducted using matched-pair comparisons, regression analysis, and analysis of covariance. Analyses found a small but statistically significant effect of skid number on wet-pavement accident rate. A linear relationship with skid number explained the variation in wet-pavement accident rate as well, or better, than any simple logarithmic or polynomial function. Differences in the slope of the linear relationship for various highway type/area type/traffic volume combinations were not statistically significant, so a single common slope was used. Slope of the wet-pavement accident rate/skid number relationship was found sensitive to the dry-pavement accident rate. The slope of the wet pavement/accident rate/skid number relationship is greater at high than at low dry-pavement accident rate, at least for rural two-lane and multilane uncontrolled access highway sections. The sensitivity of the slope of the wet-pavement accident rate-skid number relationship to dry-pavement accident rate suggests the importance of other factors related to accident causation such as highway geometrics. Predictive ability of accident rate-skid number relationships can be increased through the use of the relationships for groups of sections rather than for individual sections.

by D. W. Harwood; R. R. Blackburn; A. D. St. John; M. C. Sharp
Midwest Res. Inst.
Publ: HS-021 394 (TRR-624), "Skidding Accidents. Ancillary Papers," Washington, D.C., 1977 p142-50
1977; 9refs
Ancillary to Second International Skid Prevention Conference Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 394

assess the state of the art in ride quality as summarized by various workshop participants. The first workshop group, on accomplishments in ride quality research, concluded that field studies provide the most realistic ride environment, while single-axis simulators provide the least, although they are more controllable regarding input stimuli. The second working group focused on present and near future needs of the transportation community, specifically those of government, academic, and industrial organizations. Timetables were formulated for seven major new systems, such as an advanced transit bus and a high speed intercity bus, which were deemed necessary for enhancement of ride technology. The third workshop, on ride quality research techniques, was separated into investigations of general and scaling techniques. For the general technique group, goals were delineated, as well as analytical techniques; research approaches using scaling, medical research, and public opinion surveys; research environments; and subjects. The section on scaling techniques covers goals, magnitude estimation procedures, and multiple response measures. The fourth group, on ride control techniques, was divided into six specialty areas: aircraft ride control, marine vehicle ride control, railcar suspension design, bus/automobile suspension design, guideway roughness control, and tracked, levitated vehicle suspension. Appendices list workshop participants and detail scaling techniques.

by A. R. Kuhlthau, ed.; Anna M. Wichansky, ed.
Department of Transportation, Transportation Systems Center, Kendall Square, Cambridge, Mass. 02142
Contract NGR-47-005-81
Rept. No. DOT-TSC-OST-77-44; NASA-CP-2103; 1977; 168p refs
Availability: NTIS

HS-021 411

BICYCLE SAFETY EDUCATION: A GUIDE TO RESOURCES AND MATERIALS

An annotated bibliography has been developed as a tool for local groups planning bicycle safety education programs, with emphasis on safety materials. Also included are general bicycling resources for background and supplementary information. Wherever possible, the cost of each item is given, as well as age level for which it is intended, where it can be acquired, and a brief description of content. Resources are listed in eight sections: five curriculum guides; nine packaged programs; and 34 films and filmstrips. Twenty-two books are listed, as well as 47 pamphlets, four research reports, and four public relations materials. An index of authors/sponsors is included. Appendices present examples of ten active bicycle safety programs; public school programs are listed by state. A list of 11 periodicals with information on bicycle safety is included.

Lawrence Johnson and Associates, Inc., Washington, D.C.
Contract CPSC-C-77-0027
1977; 75p
Prepared in conjunction with a national bicycle safety education conference: Bike-Ed '77. Jointly sponsored by Dept. of Transportation and Consumer Products Safety Commission.
Availability: Department of Transportation

exercise of police power, even though courts are not in agreement on the rationale for upholding such legislation. Constitutional challenges to state legislation raise the difficult legal and philosophical question of whether and to what extent government may act to protect people from their own indiscretions. Passage of the Federal-Aid Highway Act (P.L. 94-280) curbed the power of the Dept. of Transportation to penalize states that do not enact helmet legislation. States may, however, be subject to penalties for not requiring persons under 18 years of age to wear helmets. Historical developments in and the legal basis for helmet legislation are addressed. Four considerations are cited which strengthen the constitutionality of such legislation: public interest, not the interests of a particular person or group, requires interference with individual rights; means of carrying out the public interest must be reasonably necessary and not duly oppressive upon individuals; general presumption of constitutionality afforded statutes passed by legislatures; and plenary power of states over their highways to regulate for the safety and best interests of the public. Arguments against helmet legislation are categorized as attacks on the purpose of helmet use statutes and attacks on means of furthering the public purpose. The latter category includes such arguments as denial of equal protection, vagueness, illegal delegation of powers, infringement on the right to travel, and abridgment of freedom of speech.

by Paul A. Ruschmann
Highway Safety Res. Inst., Public Factors Div.
Publ: HSRI Research Review v8 n1 p4-12 (Jul/Aug 1977)
1977
Availability: See publication

HS-021 413

BRAKES: SOME COMMON BRAKING PROBLEMS...AND WHAT TO DO ABOUT THEM

Guidelines are presented to aid consumers in the identification of car brake problems and in the selection of a suitable repair shop. Places for brake repair include service stations, service shops of chain department stores, independent general repair shops, specialty brake shops, tire stores, and new car dealerships. If there are a lot of cars around a shop, chances are that the mechanic is busy and also good. If the shop is accredited to do brake work or the owner is a member of a professional automotive association, it is probable that both shop and mechanic are better than average. In many cases, new car dealerships employ competent mechanics. It is pointed out that a small independent repair shop has more to lose than a large organization if the brake work is not satisfactory. The "do it yourself" approach is recommended only for the competent mechanic with the proper tools. Procedures for inspecting brakes to determine if there is a problem and to evaluate work performed are detailed. The importance of being aware of materials used in brake repair and the significance of cost are stressed. Symptoms and causes of brake trouble are noted as a low pedal, pulling or dragging, a hard pedal, noises, pedal pul-

sation, and front brakes that heat up and will not release. Brake system functions are illustrated in a schematic.

by Walt Woron
Publ: Motor Trends v29 n10 p95-100, 102 (Oct 1977)
1977
Availability: See publication

HS-021 414

MASS AIR FLOWMETER MEASURES AIR INTAKE ULTRASONICALLY

A novel concept developed by Fiat for a mass air flowmeter to improve control over engine air to fuel ratios consists of a duct with a circular section containing two piezoelectric microphones located at fixed points along its axis. When these devices are excited by a voltage pulse, they emit ultrasonic energy whose maximum amplitude corresponds with their natural resonance (about 300 kHz). As soon as transmission is completed, both devices begin to work as receivers. The time elapsed between the reception of sound which propagates in the direction of air flow and that which propagates in the opposite direction is closely related to air velocity. Working principles of the flowmeter are detailed, as well as its electronic aspects, features, and limitations. It is capable of maintaining a constant air to fuel ratio. The experimental results of coupling the flowmeter with a three-way catalyst have been encouraging in that they reconfirmed the narrowness of the operating window for minimizing polluting emissions. The flowmeter control system is based on the use of a microcomputer installed in cars that is suitable for dynamometer and road tests. The ultrasonic mass air flowmeter is graphically illustrated, and data on ultrasonic wave transmission and reception and on typical waveforms of a mass flow signal are provided.

Publ: Automotive Engineering v85 n10 p59-62 (Oct 1977)
1977
Based on SAE-770855 by R. Rinolfi.
Availability: See publication

HS-021 415

SPLITTING THE CRANK FOR V-6 [ENGINE] SMOOTHNESS

The approaches taken by Buick and Chevrolet to minimize V-6 engine imbalance involve retention of the V-6 engine at 90° and development of novel crankshafts to mitigate imbalance and uneven firing. Both designs show innovation in meeting often conflicting objectives of engineering economy, performance, and fuel economy. Buick, however, opts for even firing and the elimination of primary vertical imbalance, while Chevrolet trades even pulses for enhanced balance overall. The Buick crankshaft's split rod journals displace adjacent throws 15° in opposite directions for a total displacement of 30° between adjacent firings. To compensate for the secondary imbalance caused by the rotating couple not being of constant magnitude, underbalancing is used to eliminate the vertical component of the couple. The Chevrolet crankshaft has 18° split pins yielding firing intervals of 132° and 108°. This achieves a 62% reduction in torque fluctuation. The approaches taken by Buick and Chevrolet and associated hardware are described in detail. Photographs and graphical illustrations of engine design and modification are included, along with data on balance characteristics of several engine configurations, torque variations, and balancing options.

Publ: Automotive Engineering v85 n10 p64-9 (Oct 1977)
1977
Based on SAE-770821, "Buick's New Even Firing 90-Deg V-6 Engine," by Dennis M. Manner and Richard A. Miller and on SAE-770822, "Chevrolet's New 90-Deg V-6 Engine," by John S. Zwerner.
Availability: See publication

HS-021 416

WHAT THE DISTILLING INDUSTRY IS DOING ABOUT DRINKING AND DRIVING

The Distilled Spirits Council of the U.S. (DISCUS) supports the concept of "Know Your Limits" campaigns that are based on normative drinking practices identified in scientific, governmental, and professional literature. Responsible drinking advertisements promoted by DISCUS are also based on these practices. Advertising messages for teenagers recognize the importance of adult behavior as a model for responsible decisionmaking. Specialized appeals have been made by DISCUS in conjunction with national organizations and efforts concerned with alcohol abuse. The supportive program of DISCUS includes high school student education; studies of the causation, prevention, and treatment of alcoholism and related problems; adult training in the determination of blood alcohol levels; a model course in the diagnosis and treatment of alcoholism at Harvard Medical School; the development of objective source materials for alcohol education in schools; and the provision of information on alcohol consumption. Industry efforts and publications to minimize alcohol abuse problems include voluntary exclusion of liquor advertizing from television and radio, publication of materials promoting DISCUS' responsible-drinking message, and cooperation with highway safety programs.

by P. F. Gavaghan
Publ: Traffic Safety v77 n8 p8-10 (Sep 1977)
1977
Availability: See publication

HS-021 417

TRAFFIC SAFETY TRAINING AT THE GRASS ROOTS LEVEL

A community traffic safety planning workshop was developed by the National Safety Council to train local officials with traffic safety responsibilities in working to organize a local traffic safety commission, analyze community traffic safety problems, devise programs to resolve problems, and evaluate the effectiveness of programs once they are operational. The text of the course embodied in the workshop consists of eight modules, each covering a different phase of traffic safety planning on the local level and each designed as a self-contained unit that may be separated from the others for possible use as a mini-course. Titles of the eight modules are the following: traffic safety efforts; what a local organization does; who makes up a local organization; identifying local traffic safety problems; developing written program goals and objectives; planning, scheduling, and implementing traffic accident countermeasures; developing and conducting public information and education programs; and evaluating traffic safety programs. Four pilot workshops were held in Indiana (South

Bend, Kokomo, Bloomington, and Jeffersonville). The chief of the New Albany, Ind. Police Dept. rated the Jeffersonville workshop as highly useful. In general, students felt that the workshop should be longer and that more visual aids should be used. Data from the evaluation forms and test scores of all four workshops showed that 82% rated the workshop course at six out of ten points or better and that 80% found the workshops useful in their full time occupations. Overall, the modules on recordkeeping and accident countermeasures were reported as most useful. An analysis of test scores revealed that students demonstrated an increased knowledge about traffic safety programs.

by Robert B. Overend
Publ: Traffic Safety v77 n8 p14-6, 38-40 (Sep 1977)
1977
Availability: See publication

HS-021 418

CAR SAFETY RESTRAINTS FOR CHILDREN

The results of testing various car safety restraint devices for children are presented, and suggestions to aid in the safe use of such devices are offered. The test group consisted of the following models: Ford Tot Guard, Sears Child Safety Harness 6401, Peterson Reclina Model 67B, Bobby Mac 3-in-1 Baby Chair 4810, General Motors Love Seat, Chrysler Child Safety Seat, and Irvin Child Car Seat and Safety Cushion Model 1165. To simulate actual crash conditions, an acceleration sled was employed that was equipped with a front bench seat, a floor pan, and a simulated instrument panel. Front, side, and rear impacts were investigated in the course of testing. Three of the seven devices provided at least adequate protection (General Motors Love Seat, Ford Tot Guard, and Bobby Mac 4810). The remaining four devices were rated as not acceptable. It is recommended that child restraints not be mounted on a folding car seat without positive latches and that they generally be used in the back seat of most two-door cars built before 1968. In four-door and late model two-door cars, child restraints should be mounted in the center of the rear seat, away from sides and doors. Photographs of the seven devices tested are included, and a rating for each device in terms of its lifesaving performance and quality and cost data are provided.

Publ: Consumer Reports v39 n2 p108-12 (Feb 1974)
1974
Availability: See publication

HS-021 419

AN EVALUATION OF A LABORATORY TECHNIQUE FOR MEASURING TREAD WEAR ON PASSENGER CAR TIRES FOR THE RMA [RUBBER MANUFACTURERS ASSOCIATION, INC.]. FINAL REPORT

The feasibility of using Calspan's Tire Research Facility (TIRF) for realistic simulation of tire road wear was investigated by testing high mileage radial ply tires and low mileage bias ply tires against bias type control tires. Electromechanical tread wear measurement instrumentation was developed and used to determine tire wear rates. Six tires were subjected to a test run of 1000 miles following a 15 minute break-in period to stabilize the tires; average tire tread surface temperatures were 98° to 116° F. Cornstarch was used on the tire/roadway interface to get the realistic smooth tread surface texture rather than the coarse, tacky surface characteristic of the laboratory environment. Tests to measure repeatability showed instead a consistent decrease in wear rate for which an explanation is not available. The tire may possess such a characteristic, or belt wear may be responsible. The contamination that occurred of the roadway surface can be cleaned by mechanical means. TIRF-determined wear rate data do permit a gross rank ordering of the test tires according to high, control, and low mileage tires. The high mileage radial tire shows the least wear, the bias (control) tires shows an intermediate level of wear, and the low mileage bias tire shows the largest wear rate by a factor of two relative to the radial tire. Future tests should simulate variations in lateral force instead of slip angle, and in tractive force instead of input wheel torque.

by L. Bogdan; I. Gusakov
Calspan Corp., Buffalo, N.Y. 14221
Rept. No. ZM-5974-T-1; 1977; 76p 3refs
Availability: Reference copy only

HS-021 420

SITE REPORT. KANSAS CITY, MISSOURI [ALCOHOL SAFETY ACTION PROGRAM]

The Kansas City, Mo., Alcohol Safety Action Project (ASAP) encompasses the greater metropolitan area, population 1.3 million, with enforcement measures directed primarily to the city itself, and to the police department, which had 955 officers in 1970. During 1970, 2300 persons out of 26,400 accidents were identified and arrested as driving-while-intoxicated (DWI) offenders. Principal project findings indicate that, while 20% of all traffic law offenders are Kansas residents, the Missouri State Motor Vehicle Bureau cannot efficiently obtain prior driving records of those individuals. License suspensions and revocations are less than fully effective because the state driver's license has no photograph, making positive identification difficult, and drivers sometimes possess both Missouri and Kansas licenses. The theory and intent of the implied consent statute is not always observed in actual practice; defendants refuse to take the chemical test because they can establish "hardship" fairly easily and continue to drive. Findings indicate that the assessment of points for driving while intoxicated offenses varies depending on whether the defendant is charged under the provisions of state statute or local ordinance. Legal statutes applying to the drinking problem, state and local, include driving while intoxicated; breath test consent, refusal, and use as evidence; and proposed local statutes. Kansas City's ASAP program works with, and is affected by, the State Department of Revenue, local and state interagency relationships, law enforcement resources, and accident and enforcement statistics. Among the recommendations for legislative and judicial changes are the following: make the determining blood alcohol (BAC) 0.10; fingerprint and photograph those convicted of DWI; assess 12 points for a DWI offense uniformly throughout the state; place color photographs on drivers' licenses; and improve content and interface of existing data bases concerning drivers and driving conviction data. Other recommendations include improvement of coordination between state and city law enforcement agencies and programs, and increased emphasis on enforcement and pre-accident apprehension type measures of the ASAP.

1971; 29p
Availability: Corporate author

HS-021 421

TRANSPORTATION SAFETY INFORMATION REPORT, APRIL, MAY, AND JUNE 1977. FINAL REPORT

National transportation safety statistics show that total transportation fatalities rose by 0.6% as compared to the same period in 1976. Air carrier and pipeline modes had significant increases in fatalities, while fatalities declined in the category of general aviation, recreational boating, and railroad. Fatalities from hazardous materials incidents rose, while rail/highway grade crossing fatalities declined. As for highway and traffic mode, there was a 0.8% increase in fatalities: 11,683 fatalities compared with 11,591 in 1976. Three case reports of accidents are presented to show the safety effects of air-cushioned restraint systems (air bags). Work in the area of highways and traffic included a warning on Ford fan blades, awarding of contracts to Minicars and Calspan Corp. for work on research safety vehicles, administration of the National Driver Register, and analysis of lapbelt use. Other work included identification of potential defects via accident research, development of an automatic tread gaging machine, a report on the lifesaving 55 mph speed limit, and demonstration that motor vehicle and highway safety improvements of the last decade have saved 200,000 lives. In addition, work continued on the technology of vehicle detector placement for traffic-actuated signals, speed studies made in construction zones, execution of the pavement marking demonstration program, and compilation of bus accident statistics. Programs in other areas of transportation are reviewed. Feature articles concern crash protection due to occupant restraint systems and automotive occupant restraint systems in particular. A glossary is provided.

Department of Transportation, Transportation Systems Center, Kendall Square, Cambridge, Mass. 02142
Rept. No. DOT-TSC-TES-77-2; NTISUB/C/224-002; 1977; 73p
Availability: NTIS

HS-021 422

CODEBOOK WITH MARGINALS. WASHTENAW COUNTY GENERAL PUBLIC 1971 SURVEY ON DRINKING AND DRIVING

Household interviews were conducted with 606 residents of Washtenaw County, Mich., aged 16 and older during the period 13 Feb to 25 Jul 1971. Interviews represent a response rate of 76.2% from among the 795 eligible respondents in the representative sample. Some responses were obtained via four-page mail-back questionnaires when interviews could not be arranged. Data are coded under 20 headings by variables: sampling, interviewing, and coding information; accident causation and the role of alcohol; accident knowledge and precautionary behavior; attitudes toward general highway safety measures; safe/legal amounts of alcohol and accident risk; knowledge of importance of factors affecting alcohol influence; knowledge of sobering up methods; implied consent and use of breath tests; attitudes toward punishment/deterrence drunk driving measures; attitudes toward alcohol help drunk driving measures; attitudes toward and awareness of educational drunk driving measures; local extent of and help for alcohol problems; support for and awareness of alcohol safety programs; own drinking behavior and attitudes; perceived importance of various reasons people drink; responsibilities of servers of alcohol and own behavior; own driving experience and record; own behavior in regard to drinking and driving personal background of responsdent; and own local media use. For most interview variables five sets of percentage distributions are provided in the left margin. Included are total sample percentages, percentages for respondents never licensed, percentages for nondrinking drivers, and percentages of drivers who claim never to drink before driving. Moderate drinking drivers and excessive drinking drivers are also coded and percentaged. Appended are pages containing actual content of responses which did not fit into regular code categories.

by Arthur C. Wolfe; Marion M. Chapman
University of Michigan, Hwy. Safety Res. Inst., Huron Pkwy. and Baxter Rd., Ann Arbor, Mich. 48105
1972; 88p
Availability: Reference copy only

HS-021 423

LOS ANGELES CATALYST STUDY SYMPOSIUM PROCEEDINGS

Twenty-one papers deal with the Los Angeles, Calif., Catalyst Study begun in Jun 1974 to monitor, on a long term basis, ambient levels of catalyst vehicle emission products. The origins and the design of the study are explained, and previous sulfate studies in the Los Angeles Basin are examined. The rationale for selecting analytical methods is presented. Particulate ammonium in low concentrations was determined with the specific ion electrode. The thorin and modified methylthymol blue methods for determining micro amounts of sulfate are compared. Aerosols are analyzed by X-ray fluorescence. Motor vehicle gasoline specific to the Los Angeles area was surveyed. A megavolume sampler was used to collect respirable particulates. Compound identification is described. Lead recovery is compared with and without use of a low temperature asher before extraction. The percentage of diesel trucks and catalyst equipped cars is determined. Laboratory quality control and external laboratory quality assurance is discussed, as is the precision of the sampling and analysis methods. The degradation of ammonium is compared on high volume glass fiber filters and on membrane filters. Sulfate concentrations at two Los Angeles freeways is described. Continuous and integrated pollutant data are summarized. The interrelationships of nitric oxide, nitrogen dioxide, and ozone across the freeway are considered. The rationale and findings of the statistical analysis of the data are given: conclusions and recommendations are made. Some discussion of the proceedings is recorded.

by Thomas R. Hauser, ed.
Environmental Protection Agency, Environmental Monitoring and Support Lab., Research Triangle Park, N.C. 27711
Rept. No. EPA-600/4-77-034; 1977; 467p refs
Cover title is "The Los Angeles Catalyst Study Symposium." Environmental Monitoring Series; Environmental Health Effects Series. Symposium held in Raleigh, N.C., 12-13 Apr 1977.
Availability: NTIS

HS-021 424

DETECTION, DIAGNOSIS AND PROGNOSIS. PROCEEDINGS OF THE 26TH MEETING OF THE MECHANICAL FAILURES PREVENTION GROUP

(MFPG), HELD AT THE IIT RESEARCH INSTITUTE, CHICAGO, ILL., MAY 17-19, 1977

Some 24 papers constitute the proceedings of a three-day conference on detection, diagnosis, and prognosis as related to mechanical failures. The first session, on oil analysis, deals with statistical analysis of wear metal concentration, fluid analysis of oil-wetted systems, and oil compared with wear particle analysis. Ferrographic lube oil analysis is applied to U.S. Navy ship system; effectiveness of the Real Time Ferrograph and other oil monitors are discussed in terms of their relationship to oil filtration; and ferrographic separation of organic compounds is outlined. The second session, on signature analysis techniques, covers such topics as mechanical signature, spectrum, vibration signature, and signal processing. Also covered are diagnostic techniques for steam turbines, and experimental determination of radial magnetic forces. The third session, on new detection, diagnosis, and prognosis techniques and equipment, presents a new chip detector, time waveform analysis, and fluid power systems as preventive maintenance in the military. Also covered are tire degradation monitoring, use of microprocessors in analysis of acoustic emission weld monitoring data, and proximity probes for use in high temperature liquid metals environments. Railroad system diagnostics is the subject of the fourth session, dealing with the Dept. of Transportation's system for train accident reduction, and comparison of vibration analysis techniques for railroad roller bearing diagnostics. The last session, on land vehicle diagnostics, focuses on maintenance management through diagnosis; vehicle monitoring systems; and systemized diesel engine diagnostics. A list of registrants is included, and an appendix presents remote diagnostic techniques used in Viking Lander operations.

by T. Robert Shives, ed.; William A. Willard, ed.
National Bureau of Standards, Washington, D.C. 20234
Rept. No. NBS-SP-494; 1977; 301p 27refs
Availability: GPO, Stock No. 003-003-01844-9

HS-021 425

MANAGING DWI [DRIVING WHILE INTOXICATED] CASES THROUGH EVALUATION

The controversial nature of rehabilitation and treatment approaches for persons convicted of driving while intoxicated (DWI) is examined, and evaluation procedures for DWI education and treatment programs are discussed. Some persons believe that education and treatment are ineffective and may detract from the potential effectiveness of the normal enforcement/adjudication/penalty system. Others contend that education and treatment represent the only real solution to the DWI problem and promote alcohol education schools and other rehabilitation options. A primary disagreement between these opposing sides involves whether the driving or drinking aspect of the problem should receive the most attention. Both short-term and long-term impacts of education and treatment programs are considered. Evaluation of alcohol safety action projects (ASAP's) of the National Hwy. Traffic Safety Administration shows that alcohol education schools in ASAP's brought about positive changes in alcohol and traffic problems and improved attitudes toward drinking and driving, although few studies provided sound objective evidence that success in meeting intermediate objectives was reflected in terms of decreased arrests or accidents. More positive results were indicated for such rehabilitation alternatives as use of the drug Antabuse, and the Alcoholics Anonymous program. An analysis of re-arrest data at the national level revealed that non-problem (social) drinkers referred to treatment, regardless of treatment type, had significantly fewer arrests than non-problem drinkers not referred to treatment. Other evaluation efforts of the ASAP system include a short-term rehabilitation study in 1975 at 11 ASAP sites and a demonstration in 1976 to accommodate all known problems of prior ASAP research. Effectiveness evaluations are vital to program improvement.

by James L. Nichols
National Hwy. Traffic Safety Administration
Publ: Traffic Safety v77 n10 p8-10, 40 (Oct 1977)
1977
Reprinted from National Traffic Safety Newsletter.
Availability: See publication

HS-021 426

AIRBAGS: THE GREAT STATISTICAL INFLATION

No hard scientific data on airbags in terms of whether they will save lives are available. The lack of data on the Volkswagen-type passive three-point harness is noted. The validity of data collected by General Motors in an airbag pilot program conducted from 1973 to 1976 with 11,000 vehicles is questioned. In order to assess its raw data, General Motors summarized the outstanding characteristics of 132 accidents triggering airbag deployment. The results indicated that airbags are only 10% effective in preventing fatalities compared to circumstances in which passengers are totally unrestrained. Another study concluded that the upper estimate of airbag effectiveness is less than 40% of the effectiveness of lap and lap-shoulder harnesses in mitigating fatalities. The Insurance Inst. for Hwy. Safety arrived at only a marginal advantage for airbags over three-point harnesses. The use of airbags is not supported by the author for four reasons: airbags are not true passive restraints; insurance companies do not intend to grant discounts to motorists with cars having airbags; no consensus has been reached on the cost of installing and maintaining airbags; and airbags will not necessarily protect from injury the same people who would otherwise wear three-point harnesses.

by Michael Jordan
Publ: Car and Driver v23 n5 p62, 64-5 (Nov 1977)
1977
Availability: See publication

HS-021 427

DESIGNING A HEAVY-DUTY FWD [FRONT WHEEL DRIVE] AXLE

An easily serviced, 23,000 lb front wheel drive axle with a 35° turn capability, developed by the Kelsey-Hayes Co., has a steering axle which combines high load, torque, and braking capacity. Compact steering driving ends combine with an inclined kingpin to provide a small scrub radius, and the full turn capability can be realized even with the use of wide tires. A single cardan joint and heavy shafts provide an unusually durable drivetrain, disc brakes deliver excellent stopping capability, and the axle housing construction permits tailoring of the axle to a given vehicle. Designed for on or off highway service, it is said to have excellent low speed capabilities and to be stable at high speed. Four major segments comprise the axle: housing, steering driving ends, differential carrier assembly, and drive joints and shafts. Each of these segments is detailed in terms of design, construction, and interaction. The

drive end design is based on the general arrangement of other axles in the line. Testing included static load testing of a pair of steerable drive end assemblies dynamometer testing of a test axle, and in-vehicle tests such as a 2000 mile durability run at the Bendix Automotive proving grounds. Serviceability is similar to that of related axles.

Publ: Automotive Engineering v85 n9 p28-32 (Sep 1977)
1977
Based on SAE-770669 by J. Stanley L. Thomas.
Availability: See publication

HS-021 428

NEW WHEEL DRIVE CAN BENEFIT AGRICULTURAL MACHINERY

Borg-Warner Corp.'s planetary wheel drive for application to hydrostatic agricultural vehicles is a two-stage compound planetary gear set composed of seven subassemblies: input shaft and coupling, disconnect cover, primary and secondary planetary assemblies, ring gear, hub and bearings, and spindle. In applying the planetary wheel drive, the planetary device need only be bolted to the vehicle's frame in the desired location. Since it is an entirely self-enclosed unit, safety is maximized. Preventive maintenance only involves checking for proper oil level or disassembling into a series of replaceable subassemblies when service is needed. Procedures for applying the drive to agricultural vehicles are detailed. Two of the most representative uses of the drive are the self-propelled windrower or swather and the center pivot irrigation system. Advantages of the hydraulic system over the electric system include elimination of high voltage electricity, replacement of the off-on operation characteristic of electric systems with smooth metered operation, and elimination of the need to supply underground power cables to the field when diesel power is used. Other applications for the drive include pavers, sprayers, trenchers, front end loaders, harvesters, seeders, concrete mixers, and combines. A schematic and photographs are included.

Publ: Automotive Engineering v85 n9 p38-41 (Sep 1977)
1977
Based on SAE-770761 by James D. Wiggins.
Availability: See publication

HS-021 429

SUPPLYING GASOLINE FOR TOMORROW'S CARS

The outlook for gasoline consumption, quality, and supply and for refineries is projected. Overall U.S. energy consumption is forecasted by the Chevron Res. Co. to grow at an average rate of about 3% per year through 1985. The U.S. will continue to rely on oil imports, particularly the high-sulfur, heavy crudes from the Middle East. Gasoline consumption is expected to level out at about 7.5 million barrels per day after 1980. Gasoline's share of the petroleum market is then expected to drop from the historic 38% to 40% of the total product demand in 1985, from 20% in 1976. Data on the lead content of gasoline are provided in relation to Federal regulations for 1978 and 1979 and California regulations for 1977 through 1980. A graphical illustration is presented to show how U.S. refinery product output is expected to vary through 1985. Consideration is given to the distillation capacity of refineries to handle crude oil volumes required to meet anticipated product demands, gains in refinery octane potential, and expenditures and measures to upgrade the octane level of gasoline. It is concluded that, with lead phasedown and growth in the number of vehicles equipped with catalytic converters, clear octane requirements will increase significantly and that processes and facilities for upgrading the octane level of gasoline will be needed.

Publ: Automotive Engineering v85 n9 p46-51 (Sep 1977)
1977
Based on SAE-770670 by R. M. Ormiston and G. G. Pollock.
Availability: See publication

HS-021 430

TRENDS IN OFF-HIGHWAY VEHICLE ELECTRICAL SYSTEMS

At the Delco-Remy Div. of General Motors, engineers are designing a family of air and oil cooled brushless generators especially for farm, construction, and industrial machinery (FCIM) use. They are evaluating the benefits of FCIM maintenance-free batteries. To integrate generator and battery components into a cost effective package, they have developed a systems approach to FCIM electronics. The design of brushless generators is based on the following aspects of the rigorous FCIM environment: mechanical stress, environmental protection, reliability, serviceability, and electrical capacity. The advantages of air versus oil cooling are assessed. Flange mounting, with integral plumbing and drive, improves an oil cooled generator in terms of maintenance-free service, although there is some loss of flexibility in engine-to-engine application. Whether belt driven or flange mounted, it is felt that an oil cooled generator is more advantageous than an air cooled generator in terms of environmental protection, reliability, and electrical capacity. Benefits to designers offered by maintenance-free batteries pertain to durability, reliability, and serviceability. Aspects to consider in the exploitation of FCIM electronics by a systems approach are design life, onboard recording devices, finite elements, and onboard diagnosis.

Publ: Automotive Engineering v85 n9 p54-9 (Sep 1977)
1977
Based on SAE-770725 by W. S. Liston and L. J. Raver; SAE-770726 by N. R. Risenhut; and SAE-770727 by G. R. Renner.
Availability: See publication

HS-021 431

TRANSPORTATION SAFETY INFORMATION REPORT, JANUARY, FEBRAURY, AND MARCH 1977. FINAL REPORT

National transportation safety statistics show that total transportation fatalities rose by 2.1%, as compared to the same period in 1976. Air carrier and railroad modes of transportation experienced significant increases in fatalities, but were offset somewhat by highway and traffic, general aviation, and recreational boating modes. There were 8892 highway and traffic fatalities, compared with 9125 in 1976. A total of 315 railroad fatalities were reported, compared with 128 for 1976. Both air carrier accidents and fatalities increased dramatically over the same period in 1976. General aviation fatalities declined by almost 5%. Recreational boating fatalities dropped over 18%. Pipeline fatalities, resulting from incidents involving the transport of natural gas and hazardous liquid materials, declined by more than 60%. Fatalities resulting from the accidental release of hazardous materials increased from zero in the first quarter of 1976 to nine in the first quarter of 1977. The number of incidents increased by 10%, although injuries related to the incidents declined by 28%. The Transportation Systems Center conducts a variety of research and development for the various branches of the Dept. of Transportation; these are described. Work in the area of highways and traffic included the following: presentation of modal safety hazards to the Bureau of Motor Carrier Safety; limiting use of timber barricades near construction sites; development of proper signing for construction zones; a statewide accident study in Georgia; and revision of a traffic accident classification manual. Other activities included a report on pedestrian accidents, reduction of paperwork for the transportation industry, and suggestions for improving traffic control devices. Work of the National Hwy. Traffic Safety Administration (NHTSA) included maintenance of the computer software statistical package DART (Data Analysis and Reporting Techniques), study of injury severity factors in traffic pedestrian collisions, survey of attitudes toward the 55 mph speed limit, testing of foreign experimental safety vehicles, and development of plans to publish in advance all rulemaking actions. Other NHTSA work included development of a temporary-use spare tire, establishment of the National Center for Statistics and Analysis, amendment of Federal Motor Vehicle Safety Standard 111 concerning rearview mirrors, research on a collision avoidance radar brake, and a study of the effectiveness of FMVSS 121 on truck accidents. A feature article is presented on pedestrian safety, emphasizing design and construction of sidewalks separated from vehicular traffic. A glossary of terms is provided.

by William F. Gay
Department of Transportation, Transportation Systems Center, Kendall Square, Cambridge, Mass. 02142
Rept. No. NTISUB/C/244-001; DOT-TSC-TES-77-1; 1977; 77p
Availability: NTIS

HS-021 432

SKIDDING ACCIDENTS. PAVEMENT CHARACTERISTICS

A forum for international exchange of information on all aspects of wet weather skidding accidents on highways includes ten papers on pavement characteristics affecting accident incidence. Recommendations and specifications put forth by the Technical Com. on Slipperiness and Evenness for the World Rd. Congress constitute a state of the art report on pavement characteristics and skid resistance. A history of research on skid resistance of roads by the Rd. Res. Lab. (England) begin in the early 1930's with development of an apparatus to measure skid resistance reliability. The state of the art of providing pavement surfaces that reduce wet weather skidding and hydroplaning is such that microscopic and macroscopic roughness of pavement surface as well as polish wear characteristics of mineral aggregates are shown to be most important in affecting pavement friction. U.S. contributions on pavement surface characteristics to reduction of wet weather skidding accidents point to the importance of macrotexture and surface drainage of pavements to reduce effects of hydroplaning during wet weather. Texas' statewide highway safety improvement program for reducing skidding accidents during wet weather includes obtaining and reporting skid resistance information and wet weather accident information, and selecting and prioritizing locations for treatment and provision of skid resistant surfaces. The Pennsylvania Dept. of Transportation has adopted systematic procedures to obtain an economical and predictable skid resistant performance for pavements. A program for identification and treatment of high or potentially high wet pavement accident sites has been instituted in Virginia. The Federal Aviation Administration (FAA) has promoted runway grooving and use of porous friction course overlays; friction survey procedures, measurement parameters, data acquisition, and cleaning methods are considered. The Air Force has done research on runway skid resistance and hydroplaning and has developed a runway evaluation system using the mu-meter and the diagonally braked vehicle (DBV). Transport Canada has established standards of minimum coefficient of friction for runways, and procedures and instruments for measurement, and periodically assesses runway surface conditions.

National Acad. of Sciences, Transportation Res. Board, 2101 Constitution Ave., N.W., Washington, D.C. 20418
Rept. No. TRR-622; 1977; 117p refs
Proceedings of Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977. Abstracts in French and German.
Availability: Corporate author $4.60

HS-021 433

PAVEMENT CHARACTERISTICS AND SKID RESISTANCE

Recommendations and specifications put forth by the Technical Com. on Slipperiness and Evenness for the World Rd. Congress in Prague (1971) and Mexico (1975) constitute a state of the art report on pavement characteristics and skid resistance. Standards and specifications of skid resistance properties and materials vary by country, and by new versus existing pavements. For new pavements the specifications dealing with materials are important, in particular the polished stone value used for wearing courses, minimum macrotexture requirements, and direct measurement of friction. European countries especially show a trend toward clearer definition of the responsibility of the contractor to ensure given skid resistance levels. Systematic measurements of pavement skid resistance can be carried out at moderate cost, particularly if high efficiency equipment is used rather than manual methods. Systematic measurements allow the highway engineer to program maintenance work in order to obtain a predetermined skid resistance value on the network. Measurements can be used for accident prevention once a relationship has been established between skid numbers and accidents. Skid resistant

pavements are usually of several types: bituminous concretes without chippings, or with precoated chippings; gussasphalts (conventional or rolled); tarmacadams and bitumacadams; and grooved, cement concrete surfaces. An economical choice should be made with regard to possible use of local materials, workmanship of contractors, and experience of the highway engineer. Restoration techniques of skid resistance properties of pavements are used on both bituminous and cement concrete, either on "black spots" or over the whole network. Techniques involve either removal or addition of material. Rolling noise is a problem in skid prevention which necessitates a compromise between safety and environment.

by P. M. Elsenaar; J. Reichert; R. Sauterey
State Rd. Lab., Rd. Measurements Dept., Delft, The Netherlands; Centre de Recherches Routieres, Bruxelles, Belgium; Laboratoire Central des Ponts et Chaussees, Prevision du Controle et de l'Information, Paris, France
Publ: HS-021 432 (TRR-622), "Skidding Accidents. Pavement Characteristics," Washington, D.C., 1977 p1-25
1977; 54refs
Presented at Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 432

HS-021 434

RESEARCH ON SKID-RESISTANCE AT THE TRANSPORT AND ROAD RESEARCH LABORATORY

Research on skid resistance of roads began at the Rd. Res. Lab. (now the Transport and Rd. Res. Lab.) in the early 1930's, beginning with development of an apparatus to measure skid resistance reliability, and has continued to the present time. The early machine was an adapted motorcycle and sidecar, the sidecar wheel being mounted at an angle to generate a sideway force. This was later superseded by inboard systems in front-wheel drive cars and has led to the present day commercial production of a sideway force routine investigation machine (SCRIM) which is available for general use and which produces an automated output suitable for computer processing. A gradual evolution is seen in skid resistance standards, which has led to specification of materials to give levels of microtexture necessary for the nominated low speed skidding values to be maintained. Developments have occurred concurrently in bituminous and concrete surfacings; for the former, sideway force coefficient appears to be simply related to traffic volume for any aggregate of given polished stone value. Other aggregate characteristics beyond resistance to polishing are important in determining resistance to skidding of a bituminous surfacing, such as geological group and particle size. For equivalent performance, the transverse texture of a concrete surfacing can have a lower average value than the random texture of a bituminous one. Standards of skid resistance have been proposed, divided into four categories by type of site, but regulations have not been formulated, due to legal implications. A noise study concluded that although deep grooved concrete creates more noise than a typical bituminous surfacing, it provides greater benefit in terms of high-speed skid resistance. Studies on road spray indicate that distributions of water on the surface of rolled asphalt and brushe concrete during rainfall are quite similar.

by G. F. Salt
Transport and Rd. Res. Lab., Crowthorne, United Kingdom
Publ: HS-021 432 (TRR-622), "Skidding Accidents. Pavement Characteristics," Washington, D.C., 1977 p26-38
1977; 25refs
Presented at Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 432

HS-021 435

PROVIDING SKID RESISTANT PAVEMENTS

State of the art of providing pavement surfaces that reduc wet weather skidding and hydroplaning are summarized ar reviewed. Microscopic and macroscopic roughness of th pavement surface as well as polish/wear characteristics mineral aggregates are undoubtedly the most important facto affecting pavement friction. Pavement materials can categorized and selected according to shape, size, and wear r sistance. Development of a standardized laboratory device f wear and polish studies is important, especially in areas of th U.S. where limestone aggregates are the main supply sourc A laboratory test method is needed which will produce te specimens, wear and polishing techniques, and proper metho of measuring friction which will predict changes tire/pavement friction over the entire vehicle speed rang Design of the pavement wearing course is a factor in achievi a skid resistant roadway. Portland cement concrete; m design; air entrainment; aggregates, fine and coarse; asphi concrete; slurry seals; and aggregate seal coats, if careful selected and combined with the right cementing agent, a durable, structurally stable, and noise-minimizing desi characteristics. Construction methods, outlined for Portla cement concrete and asphalt surfaces, must follow specifi methods in order to achieve durability and satisfactory init skid resistance. Maintenance of both types of surfaces, ev covering the existing surface, is often necessary to mainta satisfactory skid resistance properties. Recommendations c the need for development of laboratory methods, and for i tensive study of construction practices.

by John L. Beaton
Publ: HS-021 432 (TRR-622), "Skidding Accidents. Pavement Characteristics," Washington, D.C., 1977 p39-50
1977; 33refs
Presented at Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 432

HS-021 436

PAVEMENT CONTRIBUTIONS TO WET-WEATHER SKIDDING ACCIDENT REDUCTION

State of the art of U.S. contributions of pavement surfa characteristics to reduction of wet-weather skidding accide is reviewed, with emphasis on road and street pavemen Braking deceleration patterns may be useful in determini skid resistance requirements at intersections and other braki sites. There is increasing recognition of the importance macrotexture and surface drainage of pavements to reduce fects of hydroplaning during wet weather. Use of adequ cross slope, particularly on long radius curves, open-grad asphaltic concrete surfaces, and grooved or tined portland

ment concrete surfaces should result in reductions in wet weather accidents. There is no generally accepted method for measuring hydroplaning potential of pavements; however, use of skid resistance values combined with the skid resistance speed gradient provides the best currently available approach for evaluating wet-weather performance of highway pavements. Skid resistance, described as the skid number (SN) measured in accordance with American Society for Testing and Materials (ASTM) Method E-274, is the most generally used method of characterizing roadway pavements. Texture and surface drainage are becoming increasingly recognized as characteristics to be considered. The method of skid resistance measurement in widest use in the U.S. uses properly calibrated locked wheel skid trailers conforming to ASTM Method E-274. No nationally accepted pavement surface characteristics requirements have been established. An SN of 37 measured at 65 km/h is the most generally recognized surface requirement for main rural highways with a mean traffic speed of 80 km/h. The Federal Aviation Administration (FAA) has published guidelines for airfield pavements: their construction, and such maintenance features as texture, contaminants, paint marking areas, abnormalities, friction requirements, and survey procedures. Many unresolved questions remain, such as acceptable wet-to-dry pavement accident ratios, minimum standards, and measurement equipment for highway skid resistance.

by Harry A. Smith
Transportation Res. Board, NCHRP, Washington, D.C.
Publ: HS-021 432 (TRR-622), "Skidding Accidents. Pavement Characteristics," Washington, D.C., 1977 p51-9
1977; 23refs
Presented at Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 432

HS-021 437

A PROGRAM FOR REDUCING SKIDDING ACCIDENTS DURING WET WEATHER

Texas' statewide highway safety improvement program for reducing skidding accidents during wet weather includes obtaining and reporting skid resistance information and wet weather accident information, and selecting and prioritizing locations for treatment and provision of skid resistant surfaces. It is difficult to use information for accident reduction due to delays in obtaining such information. Skid resistance information can, however, be collected in an automated manner using numbered construction jobs as the categories for information which is stored in automated files. Thus a skid resistance performance history can be formed for various types of pavement and materials. Accident information is maintained by means of several reports, one of which is available annually for every state-maintained rural highway, subdivided by county. Skid prone locations are determined for spot locations and long sections, and project priorities are ranked according to SPI (statewide priority rating). Provision of skid resistant surfaces is approached through portland cement and asphaltic concretes, penetration seals or surface treatments, sprinkle treatment, and rehabilitation of surfaces. Dense or open graded mixes, sprinkle treatments, and penetration seals have been used as overlay rehabilitation methods. Two general methods of corrective action include frequent local reporting and treatment, and long term treatment used on annual information.

by Kenneth D. Hankins
Texas Dept. of Highways and Public Transportation
Publ: HS-021 432 (TRR-622), "Skidding Accidents. Pavement Characteristics," Washington, D.C., 1977 p72-84
1977; 9refs
Presented at Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 432

HS-021 438

DEVELOPMENT AND IMPLEMENTATION OF A PROGRAM TO REDUCE SKID ACCIDENTS

The Pennsylvania Dept. of Transportation (PennDOT) has adopted systematic procedures based on a long history of research and development to obtain an economical and predictable skid resistant performance for pavements. Four single wheel testers are operated routinely and continuously, in accordance with American Society for Testing and Materials (ASTM) Method E-274. Testing activities include wet pavement accident surveys, special request testing, research project skid testing, and routine survey testing. Skid tests results are used to guide corrective action on pavements with low skid resistance. Corrective measures are the responsibility of the eleven District offices of PennDOT. An ID-2 dense graded bituminous concrete is the prevalent corrective surface on both existing concrete and bituminous surfaces, with grooving sometimes used. Although coarse aggregate properties have the major influence on skid resistant surfaces, attention is also given to mix design, with due consideration to asphalt content and fine aggregate. Skid resistance level (SRL) designations for an aggregate are based on its performance in properly designed, dense graded bituminous surfaces. SRL ratings include five categories from excellent to low. Continuing research should be able to develop methods to predict low values for the time of year tested.

by Wade L. Gramling
Pennsylvania Dept. of Transportation
Publ: HS-021 432 (TRR-622), "Skidding Accidents. Pavement Characteristics," Washington, D.C., 1977 p85-90
1977; 9refs
Presented at Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 432

HS-021 439

VIRGINIA'S WET PAVEMENT ACCIDENT REDUCTION PROGRAM

A systematic program for identification and treatment of high or potentially high wet pavement accident sites has recently been instituted in Virginia. The program pertains to interstate, arterial, and primary roadway systems maintained by the state. Accident data, used to identify sites which need correction, and data collected in Virginia's survey skid program constitute the two data bases used to determine high and low potential wet accident sites. A wet pavement accident skid number of 30 has been selected as a tentative minimum guideline. The site review process is divided into six stages, the first being development of accident site information, based on accident or survey skid data. The second stage is development of surface mix site information, involving determination of the surface

mix section within which the accident falls, and compilation of relevant accident and skid data. The next phase, an initial economic analysis, determines cost of improvements compared with savings in accident and property damage. Priority ranking for field review is then assigned on the basis of lowest to highest breakeven values. Then a field review gives careful attention to geometrics, traffic turbulence, sight distance, roadside development, traffic control, posted speed limit, and general pavement surface condition. A judgment evaluation as to prime causative factors in wet pavement accidents is thus allowed. Final economic analysis determines treatment to be used, and total cost. Each site is evaluated on the basis of accident and skid data annually for three years following treatment.

by Stephen N. Runkle; David C. Mahone
Virginia Hwy. and Transportation Res. Council
Publ: HS-021 432 (TRR-622), "Skidding Accidents. Pavement Characteristics," Washington, D.C., 1977 p91-9
1977; 11refs
Presented at Second International Skid Prevention Conference, Columbus, Ohio, 2-6 May 1977.
Availability: In HS-021 432

HS-021 440

THE USE OF DIGITAL FOURIER TRANSFORM METHODS IN ENGINE NOISE RESEARCH

Methods of reducing engine noise include vibration isolation, close cladding and engine enclosure, and reduction of clearances in the engine such as that of the piston within the cylinder. The process of diesel engine noise is described, and the application of digital Fourier transform (DFT) techniques to radiated noise as it relates to pressure-time histories in engine cylinders is detailed. It is assumed that the engine is a linear system so that the catenation of events between excitations and the arrival of a noise signal can be combined to form a multiple input-response system. DFT techniques involving the use of transfer and coherence functions are applied to predict the effect of the rapid rise in cylinder pressure that is typical of naturally aspirated diesel engines on noise. Data are presented for a four-cycle six-cylinder engine, and supporting equations are given. Linear theory for a structural acoustics system is discussed. A rapid rise in cylinder pressure has a significant effect on engine noise.

by J. Y. Chung
General Motors Res. Labs., Fluid Dynamics Res. Dept.
Rept. No. SAE-770010; 1977; 12p 11refs
Presented at International Automotive Congress and Exposition, Detroit, 28 Feb-4 Mar 1977.
Availability: SAE

HS-021 441

ON FACTORS OF NOISE EMITTED BY A SMALL VEHICLE AND NOISE LEVEL SIMULATION OF PASS-BY TEST

To achieve a reduction in the exterior noise of a small vehicle at an early stage of design, an attempt was made to estimate the pass-by noise of the vehicle (ISO R-362 test standards) from measurements of the noise of the engine and exhaust system units in bench tests. Fully open throttle acceleration was carried out over a distance of 20 meters plus the vehicle's length, and the maximum dB(A) level measured by microphones located on either side. The peak acceleration noise level can be obtained from the noise levels of th sources corresponding to the engine speed and the noise lev decrement with the distance between the vehicle (noi sources) and the microphone. A series of graphs illustrates t noise measurements. By acceleration noise simulation the fo lowing analyses can be made: the contributions of noi sources can be computed; in reducing the acceleration noi level, the target of reduction at each noise source can clarified; it is possible to estimate the reduced value of a celeration noise when the source noise is reduced to a s level; and in changing the vehicle specifications, the effects the change can be easily estimated. Simulation repetition easily accomplished simply by changing the parameters vehicle acceleration performance characteristics. The freque cy spectrum of the noise source should be taken into accou to more precisely estimate noise level and noise spectru since the characteristics of noise propagation depend frequency.

by Kaoru Masuko; Takeshi Abe
Nissan Motor Co., Ltd., Japan
Rept. No. SAE-770011; 1977; 15p 2refs
Presented at International Automotive Engineering Congress and Exposition, Detroit, 28 Feb-4 Mar 1977.
Availability: SAE

HS-021 442

COMBUSTION NOISE AND IGNITION DELAY IN DIESEL ENGINES

Tests were carried out on a current prechamber diesel eng in different running conditions, by using American Society Testing and Materials (ASTM) secondary reference fuels a experimental fuels of different hydrocarbon type compositi and cetane quality. Characteristics of the engine were 4-cyl. line engine, 1895 ccm displacement, 22.5 compression rat maximum power 47 HP DIN (at 3800 rpm), maximum torc 10.8 Kg/m (at 2200 rpm), injection timing 3° of crank angle fore Top Dead Center with automatic variation equal to CA. The test bed was equipped with an electric bra dynamometer. Combustion noise measurement was based the detection of pressure oscillations of the engine head vib tions by means of an accelerometer fixed on the engine he effective since it supplies indications that are extremely sen tive to combustion noise level variations. Results show t changes in fuel composition which do not affect ignition de can produce different combustion noise levels. Combust noise intensity was measured by changing engine speed a load. For a given cetane number, the presence of naphthenic component in the fuel can increase combust noise. Measurements taken in different engine running con tions suggest that the preheating plug is essential in order reduce combustion noise. Charts and diagrams express results of various tests; the appendix illustrates the co bustion noise measurement system as developed.

by C. Bassoli; G. M. Cornetti; G. Levizzari
FIAT Res. Center, Italy
Rept. No. SAE-770012; 1977; 14p 14refs
Presented at International Automotive Engineering Congress and Exposition, Detroit, 28 Feb-4 Mar 1977.
Availability: SAE

HS-021 443

CHARACTERIZATION OF VEHICLE DECELERATION TIME HISTORIES IN THE ANALYSIS OF IMPACT DYNAMICS

Techniques have been developed to construct a characterization of vehicle deceleration which is significantly simplified from its actual time history. The general method is that of assuming a functional (mathematical) form to approximate the time history, and then "fitting" that assumed function to the actual time history. The primary object was to effect a data (parameter) reduction with minimal loss of the essential information necessary for proper passenger compartment excitation. Two basic techniques were developed to yield a pulse characterization in which the actual vehicle deceleration is approximated by a polynomial function or a series of trigonometric functions either of which may be defined by as few as four parameters. The fidelity of each pulse approximation technique was measured in terms of comparative simulated occupant responses. The occupant simulations indicate that approximations to vehicle deceleration involving as few as four parameters are adequate to evaluate occupant dynamics with conventional restraint systems. Coincidentally, the characterizing parameters are defined by familiar physical quantities. A simple polynomial (straight line) approximation technique is used for dynamic simulation runs. The extension to a more general polynomial approximation is briefly discussed, as are sine series pulse characterization methods. These methods can be expanded to include more parameters when necessary. Results shown that polynomial and Fourier type characterizations of deceleration time histories present an interesting and practical alternative in the interpretation of crash test or simulation data.

by Matthew Huang; G. P. Lawson; B. K. Powell; J. H. Walker
Ford Motor Co.
Rept. No. SAE-770013; 1977; 11p 2refs
Presented at International Automotive Engineering Congress and Exposition, Detroit, 28 Feb-4 Mar 1977.
Availability: SAE

HS-021 444

AN IMPACT MOMENT COEFFICIENT FOR VEHICLE COLLISION ANALYSIS

The equations of impact of two colliding vehicles are derived, including the moment impulse. An impact moment coefficient is defined, whose value determines the extent to which a moment is developed across the surface of deformation between the two vehicles. It is analagous to the classical coefficient of restitution, but differs in two respects. Its range of realistic values is between -1 and 1. When it is 0, the vehicles have zero relative angular velocity following impact, but when it is -1, the angular impact is elastic. When the coefficient is 01, no moment is transmitted at impact which can be considered to be the case of direct central impact. Two examples are presented. The first is a simple classical problem of two rigid bodies impacting over a common surface, illustrating the concept of the impact moment coefficient. The second example uses data from an actual collision of two automobiles and shows that in accident reconstruction problems, an a priori value of the impact moment coefficient is often not needed. Because the impact moment coefficient depends upon the type and extent of the damaged surface which develops during an impact (and which obviously changes during the collision), the amount of mechanical interaction over the deformed surface, and the location of the center of impact, it would probably be difficult to measure during experiments. Nevertheless it may prove fruitful to attempt experimental measurements.

by Raymond M. Brach
University of Notre Dame
Rept. No. SAE-770014; 1977; 11p 13refs
Presented at International Automotive Engineering Congress and Exposition, Detroit, 28 Feb-4 Mar 1977.
Availability: SAE

HS-021 445

COMPUTER SIMULATION OF CAR-TO-CAR COLLISIONS

Verification and application of computerized car-to-car collision simulations are presented, as well as comparisons of simulation results with crash test data to indicate the degree of accuracy that can be expected with such an approach. The basic computer model, developed in 1969, has been refined to provide more general and flexible input/output capability. It treats a physical structure as a one dimensional representation, idealized in the form of discrete (lumped) masses interconnected by massless, deformable elements characterized by force/deflection properties. The model is sufficiently general to handle virtually any number of lumped masses with totally flexible connectivity. For a specifc application, lumped masses and resistive elements are defined to approximate the physical properties of the structural system under consideration. Output of the computer simulation provides a concise listing of all input parameters, acceleration, velocity and displacement time histories for each discrete mass, force and deflection time histories for each resistive element, maximum value of acceleration for each mass, and maximum value of deflection for each resistive element. Utilizing a timeshare computer service in a batch processing mode, the cost of running the collision simulations (for impact durations up to 150 milliseconds) ranged from about $10.00 to $15.00 per run. The collision interaction of three production automobiles (for which the required static force/deflection properties were available) was examined. In addition, corresponding simulations of two vehicles having modified front structures were performed to provide estimates of comparative collision performance. Force/deflection properties for these two hypothetical vehicles were, in part, based on analytical estimates. This approach has been found useful for predicting interactive vehicle collision behavior, particularly when a multitude of impact directions, velocities, and vehicle types must be considered.

by James E. Greene
Calspan Corp.
Contract DOT-HS-5-01214
Rept. No. SAE-770015; 1977; 14p 10refs
Presented at International Automotive Engineering Congress and Exposition, Detroit, 28 Feb-4 Mar 1977.
Availability: SAE

HS-021 446

THE NATURE OF SURFACES AND THEIR INFLUENCE IN WEAR MECHANISMS

The wear of materials is strongly dependent upon the nature of the solid surfaces in contact, their properties, and the nature of the films on them. Oxide films, orientation, crystal transformations, adhesive binding, crystal structure, hardness, and the presence of alloying agents are all shown to effect one

or more of the forms of wear. The three most common forms of wear are adhesive, abrasive, and corrosive. Adhesive wear occurs when the strong bonds occurring across the interface of two materials are stronger than the cohesive bonds within the weaker of the two materials. Examples depicted are gold/silicon, aluminum/copper, polytetrafluoroethylene/aluminum, and graphitic carbon/oxided chromium. Abrasive wear occurs when a very hard material contacts a softer material, or when hard particles are sandwiched between two softer surfaces; such wear is cutting or micromachining. Even the harder of the materials can be abraded; susceptibility to such wear can depend on the orientation of the material. Corrosive wear is loss of solid material due to chemical interactions of the solid surface with the environment. A substance that is a good lubricant in one environment can be a reactive agent in another; an example depicted is halogen-containing lubricants with alloys of cobalt. Effective lubrication can be considered to be a matter of controlled corrosion.

by Donald H. Buckley
National Aeronautics and Space Administration, Lewis Res. Center
Rept. No. SAE-770016; 1977; 12p 10refs
Presented at International Automotive Engineering Congress and Exposition, Detroit, 28 Feb-4 Mar 1977.
Availability: SAE

HS-021 447

ELASTOHYDRODYNAMIC LUBRICATION AND WEAR OF CAMS BEARING AGAINST CYLINDRICAL TAPPETS

A theoretical treatment is offered of the lubrication of a cam bearing against a cylindrical reciprocating tappet. The tappet lift, velocity, and acceleration are specified as a function of camshaft angle, and the effect of variations in the curvature of the cylindrical face of the tappet is explored, the cam form being modified to maintain a constant tappet lift curve. A certain tappet curvature minimizes the Hertzian pressure on the cam nose, but affords very poor lubrication conditions. To avoid high wear it is therefore necessary to purchase better lubrication at the sacrifice of higher Hertzian stresses. Appendix I offers kinematics of the contact between a cam and a cylindrically faced tappet; Appendix II, kinematics and geometry at the top of the lift.

by A. Dyson
Shell Res. Ltd., Thornton Res. Centre, United Kingdom
Rept. No. SAE-770018; 1977; 11p 4refs
Presented at International Automotive Engineering Congress and Exposition, Detroit, 28 Feb-4 Mar 1977.
Availability: SAE

HS-021 448

I. C. [INTERNAL COMBUSTION] ENGINE CAM AND TAPPET WEAR EXPERIENCE

The wear and modes of failure of commonly used cam and tappet materials include adhesive wear on scuffing, fatigue (pitting or spalling), and abrasive wear. Because of the differences in gasoline and diesel engines, the problems in these power plants are investigated separately. Successful material combinations are reviewed, and the advantages of hardenable iron cited: it yields excellent durability, being fatigue or spall relatively insensitive to variations in oil formulation and has therefore been incorporated in many engines subject to general worldwide distribution. Lubrication of nonrotating tappets and cam followers is discussed. Recommendations regarding surface finish, surface coating, and chilled iron apply equally to gasoline and diesel engines. As opposed to the effectiveness of hardenable iron in automotive gasoline engines, in diesel engines it is generally impossible to predict what material combination will be required in the environment created by a particular design. The ultimate in diesel cam and tappets today (of conventional configuration) is a cemented tungsten carbide face tappet running on a steel cam; it also works well on hardenable iron cams. The old diesel standby of chilled iron on steel still yields satisfactory performance in many engines.

by Roy F. Abell
Eaton Corp., Engine Components Div.
Rept. No. SAE-770019; 1977; 12p 10refs
Presented at International Automotive Engineering Congress and Exposition, Detroit, 28 Feb-4 Mar 1977.
Availability: SAE

HS-021 449

THE 1976 REPORTS OF THE NATIONAL ACADEMY OF SCIENCES ON THE CHLOROFLUOROCARBON-OZONE PROBLEM

Two chlorofluoromethanes, F-11 and F-12, are designated as CFM's for the purposes of the reports; other chlorofluoromethanes are not included. Findings of the CISC were that selective regulation of CFM uses and releases will eventually be necessary, and that more definite information will be provided by measurement programs now under way to reduce the present uncertainties of the bases of calculation; therefore regulatory action should be postponed until more data are available. Laboratory studies and atmospheric measurements should be given high priority. Stress is laid on the importance of conducting any future regulation "use by use," considering the relation of each use to human well-being. Informative labeling is recommended, though not as a substitute for regulation. Estimates are provided of 1975 worldwide releases of the CFM's; the necessity of international cooperation is stressed. The findings of the Panel on Atmospheric Chemistry are detailed. The reduction in stratospheric ozone by the CFM's is predicted to be 7.5% at steady state for constant 1973 release rates. Other pollutants than the CFM's include the propellant of the Space Shuttle (effects relatively small) and oxides of nitrogen emissions from fleets of several hundred SST and high altitude, subsonic planes projected for 1990 (significant reductions in ozone, in the absence of adequate emission controls). Action should not be postponed longer than two years.

by Frederick Kaufman
University of Pittsburgh
Rept. No. SAE-770020; 1977; 26p 6refs
Presented at International Automotive Engineering Congress and Exposition, Detroit, 28 Feb-4 Mar 1977. Contains the summary chapters of two National Acad. of Sciences reports, both released 13 Sep 1976: the executive summary of the report by the Com. on Impacts of Stratospheric Change (CISC) and the first chapter, "Findings," of the report entitled "Halocarbons: Effects on Stratospheric Ozone" by the Panel on Atmospheric Chemistry.
Availability: SAE

HS-021 450

CHLOROFLUOROCARBONS IN THE ATMOSPHERE -- A MANUFACTURER'S VIEW

The status of the fluorocarbon-ozone depletion theory is reviewed from the standpoint of both theoretical calculation and experimental observation. The theory states that fluorocarbons 11 and 12 are emitted to the atmosphere, diffuse upward to the stratosphere, absorb ultraviolet radiation, and photodissociate, which results in ozone-destroying chlorine atoms; reduction in ozone reduces the ability of the stratosphere to shield the Earth from the Sun's ultraviolet radiation. It is found that the mass balance calculated for chlorine species in the stratosphere is not in satisfactory agreement with direct observations. Results are summarized of the work of university and industry scientists in studying total ozone data, using modern statistical methods to measure such species as hydrogen chloride, chlorine monoxide, atomic chlorine, and the hydroxyl radical. Analysis of the data collected through the early 1970's supported the hypothesis of no change in the ozone level. The general uncertainties of the calculation together with discrepancies from observation appear to justify the National Acad. of Sciences' recommendations for continued study. Work on identification of alternate fluorocarbon materials is centering on the ethane and methane series of hydrogen-containing fluoro and chlorofluoro compounds. These are listed, along with estimates of their tropospheric lifetimes.

by S. R. Orfeo; D. F. Harnish; H. Magid
Allied Chemical Corp.
Rept. No. SAE-770021; 1977; 16p 38refs
Presented at International Automotive Engineering Congress and Exposition, Detroit, 28 Feb-4 Mar 1977.
Availability: SAE

HS-021 451

ENGINE COOLING SYSTEM DESIGN FOR HEAVY DUTY TRUCKS

A computational mode is constructed for an engine cooling system for a heavy duty truck. The required performance data for the key model elements of engine, fan, and radiator are graphed. An example is given for the cooling design engineer to demonstrate the principal use of the model in predicting cooling air-to-boil (ATB) performance and fan noise dB(A) contribution. The model is used to analyze vehicle wind-tunnel performance data. Appendix A gives a list of symbols with their definitions and physical dimensions; Appendix B concerns fan noise contribution and a modification of the fan noise equation.

by Frank G. Rising
Ford Motor Co.
Rept. No. SAE-770023; 1977; 12p 11refs
Presented at International Automotive Engineering Congress and Exposition, Detroit, 28 Feb-4 Mar 1977.
Availability: SAE

HS-021 452

ANALYSIS OF DURABILITY CHARACTERISTICS OF HEAVY DUTY RADIATORS

For the evaluation of durability characteristics of heavy duty radiators a technique has been successfully employed of relative testing, by coupling strain gauge techniques with systems modeling. Relative stress levels in various radiator components can be compared to either existing successful designs or absolute life expectancy estimated using SN curves. The preparation of a tube, critical in determining tube-to-header joint shear stress, is described. Strain gauges placed on the tubes help to identify tube stress and the loading which causes failure of the tube-to-header joint. The technique can be used to examine design modifications such as header reinforcements or ferrule design, and for determining assembly tolerances for manufacturing processing. A photograph of laboratory equipment is included.

by Gregory S. T. Millard
Borg Warner, Long Mfg. Div., Canada
Rept. No. SAE-770024; 1977; 7p
Presented at International Automotive Engineering Congress and Exposition, Detroit, 28 Feb-4 Mar 1977.
Availability: SAE

HS-021 453

AN IMPROVED COOLING SYSTEM FOR MILITARY AND HEAVY DUTY VEHICLES

The goal of an improved cooling system for the M551 (Armored Reconnaissance/Airborne Assault Vehicle) was to cool at 125° F at 17 tons gross vehicle weight. Requirements for additional ammunition, armor kits and stowage increased gross operating weight to 20 tons and also increased in-service cooling problems. Field operations have since demonstrated the need to provide for an improved cooling system design for the upweighted vehicle. The original liquid cooled system incorporated water-to-oil engine and transmission oil coolers in series with the engine radiator. The improved design separates engine and transmission heat rejection by incorporation of air-to-oil transmission cooler behind the radiator (cooling air flows in series first through the radiator, then through the transmission air-to-oil cooler). By this means reductions of engine coolant and engine oil temperature of 14° F resulted while the transmission oil temperature was reduced by 39° F. These gains were made over the best previous cooling condition in converter operation without increasing fan speed. The improved cooling system allowed for increased cooling capacity so that the 20 ton upweighted version of the vehicle could be cooled to the limit of track slip without exceeding allowable critical temperature limits. The principle of using a large area, low restriction, air-to-oil cooler for transmission oil cooling can be applied to other liquid cooled, military heavy-duty vehicles to make major gains in vehicle cooling capacity possible. Design considerations for this improved cooling system, laboratory testing at Army Tank-Automotive Res. and Devel. Command in Warren, Mich., and field testing at Army Yuma Proving Gound in Yuma, Ariz., are reported. Extensive data are provided by graphs, diagrams, and tables, with exterior and interior photographs of the M551.

by Edward J. Rambie
Army Tank-Automotive Res. and Devel. Command
Rept. No. SAE-770025; 1977; 23p 6refs
Presented at International Automotive Engineering Congress and Exposition, Detroit, 28 Feb-4 Mar 1977.
Availability: SAE

HS-021 454

BRAKE DYNAMOMETER EVALUATION OF THE DETROIT TRAFFIC ROAD TEST

As in-service testing of experimental friction materials is a time-consuming, expensive activity, the feasibility of dynamometer simulation for road tests was investigated. Braking data were collected from a test vehicle having four wheel disc brakes using a commerical disc pad material, on the Detroit Traffic Road Test. The route of this test was divided into seven segments which were analyzed individually to establish statistics on the braking profile. A profile matrix was developed as a basis in establishing a sequence of brake applications for the inertia dynamometer to simulate the braking profile for each road segment. This matrix has two parameters: vehicle velocity and deceleration rate. Dynamometer simulation tests were conducted using the developed braking profile and controlling the front brake temperature according to the brake temperatures measured in the vehicle tests. Disc pad wear was used to compare the dynamometer simulation tests against the vehicle tests, with the result that the simulation tests have more reproducible wear results than the vehicle tests. It was also found that the brake temperatures must be closely controlled to obtain consistent results, and the effects of temperature must be included in determining disc pad life and in obtaining a meaningful comparison between two friction materials.

by H. W. Schwartz; S. K. Rhee
Bendix Corp., Res. Labs.
Rept. No. SAE-770026; 1977; 12p 3refs
Presented at International Automotive Engineering Congress and Exposition, Detroit, 28 Feb-4 Mar 1977.
Availability: SAE

HS-021 455

USE OF COHERENCE AND FREQUENCY RESPONSE FUNCTIONS TO LOCATE AND DEFINE VIBRATION NOISE SOURCES IN ROLLING TIRES

In-service vibration and sound data are gathered by signal analysis techniques from radial ply truck tires to demonstrate a statistical relationship between tire vibration and sound and to identify the location and size of the vibration noise source. Data included tire vibration spectral histories, vibration-to-sound coherence, and vibration frequency response functions. The cause/effect relationship of tire vibration and sound is indicated by the coherence of sound data with tire vibration, particularly at frequencies corresponding to passage of the fundamental tread element length and its harmonics. Standing wave deformation has little influence on accurate determination of tire surface vibration levels for frequencies above 180 Hz. Tire vibration originates in the immediate vicinity of the tire/road contact patch, decaying rapidly with distance from that contact. Decay of vibration after road contact is a function of distance from the contact patch and of frequency. For a typical truck tire the region of importance for noise-producing vibration is the area within about 20 cm of the road contact patch. The tire's sidewall acts as a coherent sounding board for tread-related vibration up to a frequency of about 1000 Hz; above that frequency, sidewall vibration decays to approximately one tenth the adjacent tread vibration. For frequencies below 300 Hz the sidewall motion is approximately 180° out of phase with the tread motion.

by A. C. Eberhardt; W. F. Reiter
North Carolina State Univ., Mechanical and Aerospace Engineering
Rept. No. SAE-770027; 1977; 8p 6refs
Presented at International Automotive Engineering Congress and Exposition, Detroit, 28 Feb-4 Mar 1977.
Availability: SAE

HS-021 456

VIBRATION ANALYSIS BY DOUBLE PULSED LASER HOLOGRAPHY

In the field of sound and vibration analysis, holography is a sensitive diagnostic method; however, a double pulse method rather than the time average method is needed for the vibration analysis of internal combustion engines and car bodies. The use of a giant pulse laser with 30 ns double pulses makes it possible to holograph different phases of an object vibration within time intervals from 100 microseconds to 1 millisecond onto the same plate. The vibration phases into which the first and second laser pulse are fired can be exactly preselected by means of an electronic trigger system. The simultaneous reconstruction of the holograms taken by the first and the second laser pulse generates on the object surface a system of interference fringes which are loci of equal displacement. Adjoining fringes correspond to displacement differences of half of wavelength of the laser's light. In this way it is possible, for instance, to visualize the vibration pattern of car bodies and drive units excited by the running engine. The method of measurement and a hologram camera especially constructed for making double pulsed holograms of automobiles are described, with photographs and diagrams. Several examples of application are quoted in order to illustrate this technique, and various vibration patterns are presented.

by A. Felske; A. Happe
Volkswagenwerk AG, Res. and Devel. Div., Germany
Rept. No. SAE-770030; 1977; 20p 12refs
Presented at International Automotive Engineering Congress and Exposition, Detroit, 28 Feb-4 Mar 1977.
Availability: SAE

HS-021 457

PISTONS FOR HIGH OUTPUT DIESEL ENGINES

Piston designs used in diesel engines for commercial vehicles, railway traction, and marine propulsion include cast pistons with and without ring groove inserts, forged pistons with and without groove inserts, cast and forged pistons with cooling channel, and pistons with controlled thermal expansion. Cast iron, steels, and bronzes are used either alone or with aluminum-silicon alloys. The cast piston with groove insert is the normal design for diesel engines. Forged fullskirt pistons are stronger, but the top ring groove needs reinforcement. Controlled thermal expansion of a piston is achieved by cast-in steel struts which may enter into the oil ring groove. The cooling channel piston, having channels through which oil is forcefed to reduce temperature, can be made by either forging in cores of material later to be burned out or by electron beam welding of a forge piston body and a ring-carrying belt. Pistons of combinations of materials can be made by either mechanical interlocking (e.g. the Armal piston) or by casting, screws, or connectors (e.g. composite and articulated pistons). The

variety in piston design has come about because of such considerations as reinforcement of the top ring groove, avoidance of thermal cracking by crown and combustion rim design, and avoidance by mechanical problems by pin boss and pin design.

by Mangred D. Roehrle
Mahle G.m.b.H., Germany
Rept. No. SAE-770031; 1977; 19p
Presented at International Automotive Engineering Congress and Exposition, Detroit, 28 Feb-4 Mar 1977.
Availability: SAE

HS-021 458

SIMULATING THE LUBRICATION SYSTEM OF A DIESEL ENGINE

A complete lubrication system network analysis capability for a diesel engine is represented by a series-parallel network of flow passages and flow elements. The pressure distribution and flow rates in the network were computed according to pressure-flow characteristics of each element. The pressure-flow relationship for each network element was estimated using empirical pipe friction, expansion, and bend loss coefficients, as well as by using test rig results and a steady-state journal bearing model. The journal bearing model is basically that of the classical short bearing model with provision for heat transfer to the oil and the relative thermal growth of the journal and bearing system. When compared with diesel engine tests, the simulation predicted the pressure distribution throughout the engine and the flow rate through each branch within 10%. Predicted bearing temperature rise data agreed well with steady-state bench test results, but they were was much as 50% lower than temperature rise data measured on the engine. Although further geometric data and other information about the flow network are needed before the analysis can proceed, this capability is a valuable tool in estimating the effects of component and configuration changes on overall lubrication system performance, and provides an estimation of the overall pressure requirement of the lube system for initial pump selection. A number of graphs and diagrams provide data; appended are a list explaining nomenclature, and a solution algorithm flow chart, with the governing equations.

by E. A. Neu; J. A. Wade; A. C. Chu
Cummins Engine Co.
Rept. No. SAE-770032; 1977; 14p 11refs
Presented at International Automotive Engineering Congress and Exposition, Detroit, 28 Feb-4 Mar 1977.
Availability: SAE

HS-021 459

DESIGN AND DEVELOPMENT CRITERIA FOR AUTOMOTIVE DIESELS

A field survey of diesel engines in light commercial trucks showed that the failure profile could be described by an early failure region, indicative of manufacturing quality, and an exponential distribution, representing the reliability of the engine, merging into a log-normal wear-out region. An overall reliability of 0.9 after a year's service was judged acceptable. Major operational advantages accrue by improving the reliability further, but the cost penalties make this unattractive. Engine availability could be improved significantly, in a cost effective manner, by the selective upgrading of components and subassemblies according to their criticality. Preventive maintenance in service is not beneficial and may even degrade availability through premature aging. Conventional design criteria do not recognize the need for modifying the failure risk of individual parts and assemblies according to their likely impact on the operational behavior of the engine as a whole. An alternative methodology was derived, therefore, as part of the design and validation of a 5.8 liter (354 cu in) engine intended predominantly for the North American Class VI truck market. The three appendices analyze vehicle fleet effectiveness, maintenance and repair cost optimization, and design criteria.

by R. Bertodo
Perkins Engines Group Ltd., United Kingdom
Rept. No. SAE-770033; 1977; 16p 23refs
Presented at International Automotive Engineering Congress and Exposition, Detroit, 28 Feb-4 Mar 1977.
Availability: SAE

HS-021 460

THE APPLICATION OF PULSE CONVERTERS TO AUTOMOTIVE FOUR STROKE CYCLE ENGINES

A pulse converter is described which improves turbocharging performance by maintaining a pulse system with manifold separation and yet presenting the turbine with gases under somewhat similar conditions as a constant pressure/full admission system. In a gas dynamic model of the pulse converter, the converter is represented by a three-way branch with pressure losses. Coefficients of the pressure losses are determined from steady flow tests and included in the boundary conditions for nonsteady flow. Nonsteady tests on pulse converters fitted in a four cylinder turbocharged engine showed that using the model, predictions of the influence of pulse converter area ratio on wave form and amplitude give good agreement with experiment. Turbocharging efficiency was shown to improve with the optimum combination with a resultant increase in engine power. The combination enabled an improvement in engine backup torque characteristics to be achieved. Since the pulse converter is a simple casting of the same material as the conventional exhaust pipe, it would seem that improvement in engine performance can be achieved at either no extra cost or, due to reduction in frame size, at a reduction in cost.

by R. S. Benson; G. I. Alexander
University of Manchester Inst. of Science and Technology, United Kingdom; Liverpool Polytechnic, United Kingdom
Rept. No. SAE-770034; 1977; 35p 4refs
Presented at International Automotive Engineering Congress and Exposition, Detroit, 28 Feb-4 Mar 1977.
Availability: SAE

HS-021 461

DOES PUBLIC TRANSPORTATION OFFER PRODUCT AUGMENTATION TO AN AUTOMOTIVE COMPANY?

The future of mass public transportation is considered, in relation to the action taken by an automotive company (Volvo) to augment its product program by equipment for the Public Transportation Sector. The required economy of operation within such a company leads to a certain degree of conservatism and avoidance of risks, a policy of careful product augmentation from a safe base rather than one of massive support for new and original concepts. Alleviation of the mass transit

problem in large cities is predicted as a result of the dispersal to the suburbs of industry, shops, and offices, the development of a "continuous service society" with increased shift work preventing traffic congestion, and new means of communication replacing commuting. A flexible, easily adaptable public transportation system will still be needed, however, and for this a system of buses of varying sizes cannot be matched as far as routing, timetables, or capacity are concerned. Productivity and capacity can be increased by using exclusive bus lanes, more modern high capacity buses, efficient ticket systems, well laid-out bus stops, route improvements with the help of computer systems, and preferential treatment for buses by traffic regulation. Staggered working hours and restricted zones for cars during certain hours are often successful in providing more room for buses. The diesel engine is recommended as most efficient and economical.

by Tage Karlsson
AB Volvo, Sweden
Rept. No. SAE-770036; 1977; 10p
Presented at International Automotive Engineering Congress and Exposition, Detroit, 28 Feb-4 Mar 1977.
Availability: SAE

HS-021 462

HIGHWAY RESEARCH AND VEHICLE DESIGN FOR THE 80'S

Following the great increase in highway construction in the 1940's and 1950's, emphasis during the 1960's and 1970's has been on environmental and safety problems and energy conservation. Inflation and funding shortages are limiting major new construction; stress is now being laid on improving highway maintenance and reducing its cost, making better utilization of and upgrading existing highway facilities, and improving provision for mass transit and carpools. In the next twenty years, energy problems are likely to get more severe; shortages of certain materials will lead to use of substitute materials now being developed. Increased usage of bicycles and mopeds will also help reduce energy consumption. Further vehicle and highway improvements should reduce the death rate from accidents, provided the 55 mph speed limit remains in effect. The possible development of electric cars may produce important design and operational implications for both conventional vehicles and highways. Highway research efforts include the upgrading of highways to handle larger and heavier vehicles, affording savings in freight haulage costs, the reduction of truck noise, the development of polarized headlights, and numerous safety studies.

by David Solomon
Federal Hwy. Administration, Environmental Design and Control Div.
Rept. No. SAE-770039; 1977; 8p 5refs
Presented at International Automotive Engineering Congress and Exposition, Detroit, 28 Feb-4 Mar 1977.
Availability: SAE

HS-021 463

AN EXPERIMENTAL STUDY OF THE DELAYED MIXING STRATIFIED CHARGE ENGINE CONCEPT

Nitrogen oxide emissions from internal combustion engines were studied by using computer modeling, engine experimentation, and comparison of various authors' results. Experimental results are presented of a study using an engine configuration simulating a delayed mixing stratified charge engine. Preliminary computer studies indicated that this engine concept might produce low emissions of nitrogen oxide and still provide reasonable efficiency and power. In the delayed mixing stratified charge engine concept, a fuel-rich region is burned followed by air being mixed into the rich products. Nitrogen oxide formation was initially limited in the rich product mixtures because of the lack of oxygen, and after mixing by the relatively low temperatures due to charge expansion. A single cylinder engine was used to simulate the delayed mixing stratified charge combustion process. A rich charge was drawn into the engine through the carburetor. Combustion was initiated with a spark; later air was injected to complete the combustion process. The results showed that emissions could be controlled by the delayed mixing combustion process. The carbon monoxide emissions were equivalent to those of homogeneous engines and the hydrocarbons were lower. The disadvantage of the delayed mixing concept was its low efficiency. Some of the efficiency loss was due to burning the products of rich combustion late in the cycle, but much more was due to the work required to compress the injected air. The late burning was inherent in the process. Unless some more efficient compression arrangement can be found to compress the air internally by the power piston rather than externally, the efficiency is probably unacceptably low.

by L. W. Evers; P. S. Myers; O. A. Uyehara
University of Wisconsin
Rept. No. SAE-770042; 1977; 16p 2refs
Presented at International Automotive Engineering Congress and Exposition, Detroit, 28 Feb-4 Mar 1977. Proj. supported by the Environmental Protection Agency.
Availability: SAE

HS-021 464

TIME RESOLVED MEASUREMENTS OF THE EXHAUST FROM A JET IGNITION PRECHAMBER STRATIFIED CHARGE ENGINE

In the jet-ignition prechamber stratified-charge spark-ignition engine, the fuel-air mixture at the time of combustion is nonuniform. Instantaneous exhaust mass flow rates and emission concentrations from this engine were measured and used to determine the degree to which this charge stratification persists in the products of combustion immediately downstream of the exhaust valve throughout the exhaust process. In all the cases studied no appreciable variations, during the exhaust process, were detected either in the air-fuel ratio of the exhaust gases as a function of time or in the instantaneous concentrations of carbon dioxide, nitrogen oxides, or oxygen. The experimentally obtained instantaneous hydrocarbon and carbon monoxide concentrations in the exhaust, however, displayed large fluctuations and were used to study the sources of these two pollutants in this engine. Most of the carbon monoxide originates in the quench regions of the combustion chamber, possibly from its outer, partially reacted area or from incomplete oxidation of the zone's hydrocarbon subsequent to its formation. Hydrocarbon emissions come from cylinder head quench layers and the piston/cylinder wall crevice.

by A. Ekchian; J. B. Heywood; J. M. Rife
Massachusetts Inst. of Tech., Dept. of Mechanical Engineering
Rept. No. SAE-770043; 1977; 22p 23refs
Presented at International Automotive Engineering Congress and Exposition, Detroit, 28 Feb-4 Mar 1977.
Availability: SAE

HS-021 465

AN UPDATE OF THE DIRECT INJECTED STRATIFIED CHARGE ROTARY COMBUSTION ENGINE DEVELOPMENTS AT CURTISS-WRIGHT

Development progress of the unthrottled direct injected, Stratified Charge Rotary Combustion Engine (SCRCE) program at the Curtiss-Wright Corp. is updated since the 1974 status report. Emphasis has been on performance improvements in the automotive road/load range. The 1973 "close-coupled" injection and ignition configuration, which combines the best features of both "co-planar" and "showerhead" designs, was improved by substitution of a single-hole nozzle with a conventional automotive spark plug. This gave unprecedented firing consistency and excellent fuel consumption in the very low power regime. Sufficient fuel could not be supplied with small orifice nozzles to accommodate high power, but they proved efficient as "pilot nozzles," capable of consistent initiation of combustion; the increased fuel requirements of higher power were accommodated with an adjacent wide-dispersion "power nozzle." Since 1974 this has been the baseline configuration. The 1958-designed RC1-60 was used as the basic test vehicle: it is a single rotor engine, using test stand water and oil pumps and bolt-on drivers for injection pumps and ignition equipment. When operated as a stratified charge engine, seal lubrication is added at the intake adapter. Photographs of the engine are presented with a tabular summary of 18 of the basic variations evaluated. Various designs which have improved fuel consumption and reduced hydrocarbon emissions are described. These data show steady-state specific fuel consumption equal to or better than representative automotive diesel engines; comparable untreated emission data are presented with hydrocarbon emissions reduced to a representative band level of automotive carbureted engines and with relatively low carbon monoxide and oxides of nitrogen.

by Charles Jones; Harold D. Lamping; David M. Myers; Robert W. Loyd
Curtiss-Wright
Rept. No. SAE-770044; 1977; 25p 24refs
Presented at International Automotive Engineering Congress and Exposition, Detroit, 28 Feb-4 Mar 1977.
Availability: SAE

HS-802 148

TIRES: A BIBLIOGRAPHY

This bibliography refers to literature acquired by the National Hwy. Traffic Safety Administration (NHTSA) since its establishment in 1967, as related to the effect of tires on highway safety. Such literature includes NHTSA contract reports, reports of other organizations concerned with highway safety, and articles from periodicals in related fields. Citations follow the format used in the monthly abstract journal "Highway Safety Literature" and are indexed by a key-word-out-of-context (KWOC) listing, author, corporate author, contract number, and report number. Availability of the documents cited is given in individual entries.

by Lois Flynn, comp.
National Hwy. Traffic Safety Administration, Technical Services Div., Washington, D.C. 20590
Rept. No. SB-14; 1977; 650p
Availability: NTIS

HS-802 397

MOTOR VEHICLE BRAKE FLUID: WATER TOLERANCE AND VISCOSITY. VOL. 2. FINAL REPORT

The inservice water pickup of conventional and low water-tolerant brake fluids when used in conventional brake systems was determined, and the effects of these fluids and the water pickup on brake system components and system performance was assessed. In the testing program, a fleet of cars was used by owners for a period of two years. Three brake fluids were employed: Delco Supreme II, RM-70 Silicone base compatibility fluid (SRL 74-13), and GE SF-700 (Silicone). All 50 cars in the fleet were prepared according to standardized procedures for evaluating brake fluid moisture pickup. Brake fluid samples were taken initially and at 3, 6, 12, 18, and 24 months of service. At the end of 24 months, brake fluid remaining in the hydraulic system of cars went through bulk fluid analysis. The hydraulic system of each car was inspected for integrity at the same time brake fluid samples were taken. Brake system performance was ascertained by making a road test to detect any abnormality. Of the 50 vehicles prepared, 41 completed the testing program. The main problem encountered during the course of testing was the necessity of fluid additions. Appendices contain extensive information on the 50 cars, climatology data for San Antonio, and vehicle preparation and sampling procedural details.

by James G. Brown
Automotive Res. Associates, Inc., 5404 Bandera Rd., San Antonio, Tex. 78238
Contract DOT-HS-4-00912
1977; 133p
Rept. for Sep 1974-Jan 1977. Vol. 1 is HS-802 396.
Availability: NTIS

HS-802 479

RURAL COURTS AND HIGHWAY SAFETY

Eight recommendations have been made to the Dept. of Transportation to improve highway safety, based on visits in 1976 and 1977 to rural areas in five states, examinations of National Hwy. Traffic Safety Administration (NHTSA) evaluations of Alcohol Safety Action Programs (ASAP's), study of major policy issues, a literature review, and a study of data available in the highway safety field. NHTSA's budget should be increased for the next ten years, seeking outside revenue sources. Federal intergovernmental coordination in the drinking-and-driving field should be improved, and public educational efforts intensified. ASAP programs should be continued, with more advanced assurances of long-term local commitment; and they should be expanded in modified form to rural areas. Research in the drinking-and-driving field should be expanded, and Federal efforts coordinated to focus on economic loss research. Federal/state, intrastate intergovernmental, and public/private cooperation should be encouraged. A White House Conference on Alcoholism and Alcohol Abuse is recommended to focus public attention on safety, health, economic losses, and energy conservation potentials in improved public policies. Findings from field work related to rural courts and courts in smaller cities are coupled with previous work in urban settings obtained by subcommittee members from personal experience, national contacts, and diverse local experiences in local and state government. The realities of rural justice are that lawyers, jail facilities, and social or rehabilitation services are either nonexistent or in short supply.

Decentralized rather than centralized or circuit-riding service is characteristic of rural courts. Traffic cases are characterized by informality and use of minimal or monetary sanctions. Laymen as judges have become increasingly important. Rapid response to such traffic offenses as drunk driving is desired. Appendices include a perspective paper on alcohol, economic losses, and highway safety; and excerpts from a report to Congress on alcohol and health. A bibliography is included.

National Hwy. Traffic Safety Administration, Subcommittee on Alcohol and Adjudication, Washington, D.C. 20590
1977; 62p refs
Availability: Corporate author

HS-802 504

PEDESTRIANS: A BIBLIOGRAPHY

This bibliography represents literature acquired since the establishment of the National Hwy. Traffic Safety Administration (NHTSA) in 1967, as related to pedestrians. It contains NHTSA contract reports, reports of other organizations concerned with highway safety, and articles from periodicals in related fields. Abstract citations follow the format used in the monthly abstract journal "Highway Safety Literature" and are indexed by a keyword-out-of-context (KWOC) listing, author, corporate author, contract number, and report number.

by Lois Flynn, comp.
National Hwy. Traffic Safety Administration, Technical Reference Div., Washington, D.C. 20590
Rept. No. SB-20; 1977; 360p
Availability: NTIS

HS-802 518

TECHNICAL REPORTS OF THE NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION: A BIBLIOGRAPHY, 1976

This bibliography is an annual supplement to a previous bibliography of technical National Hwy. Traffic Safety Administration (NHTSA) reports. Abstract citations follow the format used in the monthly abstract journal "Highway Safety Literature" and are indexed by a keyword-out-of-context (KWOC) listing, author, corporate author, contract number, and report number.

by Lois Flynn, comp.
National Hwy. Traffic Safety Administration, Technical Reference Div., Washington, D.C. 20590
Rept. No. SB-21; 1977; 179p
Supplement to HS-801 200 and HS-801 895.
Availability: NTIS

HS-802 539

ULTRASONIC DETECTION OF OVERBUFFING IN RETREADED TIRES. INTERIM REPORT

The feasibility of nondestructive inspection by reflective ultrasound for damage resulting from the overbuffing of retreaded tires is examined as an alternative to the retread inspection described in Federal Motor Vehicle Safety Standard (FMVSS) 117, Retreaded Pneumatic Tires--Passenger Cars. In reflection ultrasound, narrow-band pulses of ultrasonic energy are coupled acoustically to a tire by a water envelope. This energy penetrates the tire and sends return reflections from lamina within the tire. Tabular data on the location of transducers with respect to the tire are provided. Two four-ply nylon tires were selected to demonstrate the feasibility of nondestructive inspection for overbuffing in the first part of the study. In the second part of the study, six tires (one steel belted radial, two bias belted, two four-ply polyester, and one steel belted) were retreaded and inspected by ultrasound. A comparison of inspection for overbuffing of the two tires by X-ray and reflection ultrasound conclusively showed that the latter technique was superior. Flaws of varying severity, deliberately introduced in six tires, were positively identified by reflection ultrasound in the majority of cases and were tentatively identified in the remaining instances. The X-ray technique is successful only when cords have been completely removed. The reflection ultrasound method is a viable alternative to the retread inspection under FMVSS 117 because it is reliable, cost effective, fast, and nondestructive. Photographs of the tires and ultrasonic displays are included. Recommendations for further study include a follow-up program, simplication of the system, and development of a data base.

by S. N. Bobo; A. J. Scapicchio
Department of Transportation, Transportation Systems Center, Kendall Square, Cambridge, Mass. 02142
Rept. No. DOT-TSC-NHTSA-77-4; 1977; 40p
Rept. for Jan-Mar 1977.
Availability: NTIS

HS-802 567

ACCIDENT RISK FORECASTING: A BIBLIOGRAPHY

This bibliography represents literature acquired since the establishment of the National Hwy. Traffic Safety Administration (NHTSA) in 1967, as related to accident forecasting. It contains NHTSA contract reports, reports of other organizations concerned with highway safety, and articles from periodicals in related fields. Abstract citations follow the format used in the monthly abstract journal "Highway Safety Literature" and are indexed by a keyword-out-of-context (KWOC) listing, author, corporate author, contract number, and report number.

by Lois Flynn, comp.
National Hwy. Traffic Safety Administration, Technical Reference Div., Washington, D.C. 20590
Rept. No. SB-22; 1977; 96p
Availability: NTIS

HS-802 596

SAFETY RELATED RECALL CAMPAIGNS FOR MOTOR VEHICLE AND MOTOR VEHICLE EQUIPMENT, INCLUDING TIRES REPORTED TO THE NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION BY DOMESTIC AND FOREIGN VEHICLE MANUFACTURERS, APRIL 1, 1977 TO JUNE 30, 1977

This tabulation of safety defect recall campaigns includes for each recall campaign, the National Hwy. Traffic Safety Administration (NHTSA) identification number, date of company notification, make model, model year, brief description of defect and manufacturer's corrective action, number of pages on file, and number of vehicles recalled. Types of vehicles listed

include postal delivery vehicles, passenger vehicles, motor homes, trailers, trucks, vans, police vehicles, delivery vehicles, trailers, buses, dump trucks, refuse trucks, motorcycles, mopeds, and electric trackless trolleys. Equipment listed includes helmets, helmet fasteners, axles, window glass, heaters, and tires.

National Hwy. Traffic Safety Administration, Washington, D.C. 20590
1977; 33p
Availability: GPO

HS-802 598

SAFETY BELTS: THE UNCOLLECTED DIVIDENDS. A MANUAL FOR USE BY STATE LEGISLATORS AND STATE OFFICIALS ON TECHNIQUES TO INCREASE SAFETY BELT USAGE. FINAL REPORT

A manual for use by state legislators and other officials is an aid to promote the use of safety belts as the most cost-effective highway safety measure that can be adopted by any state. An overview of safety belt effectiveness is presented, and a statewide coordinated plan to increase safety belt usage is described that includes a coordinating committee, an executive committee, subcommittees, and a key coordinator. Techniques for increasing safety belt usage are linked to state agencies having primary responsibility for the particular area. Ten areas are considered: police traffic services, accident investigation, traffic accident records, traffic courts, infant and child restraints, periodic motor vehicle inspection, driver licensing, driver and traffic safety education, codes and laws, and public information and education. The police officer who supports safety belt use brings to the cause the influence inherent in the uniform. Accident investigation is information gathering and reporting for use in later statistical analysis; such information includes use of safety belts, crash configuration, human injury and vehicle damage. The National Accident Sampling System (NASS), still in a pilot stage, will contain nationally representative data. State traffic records systems should include information on safety belt use as part of their accident reporting system. If judges are educated about the value of safety belt use they can be influential in dealing with traffic safety cases. The courthouse is a good place to display and give away materials promoting safety belt use. Use of infant and child restraints can be promoted by the physician and by programs to recycle restraint systems. Periodic motor vehicle inspection should include inspection of safety belts. Driver licensing procedures should require both knowledge of safety belt use and use of safety belts during the driving test. Driver and traffic safety programs in the schools should strongly promote safety belt usage. Legislation can mandate either the presence of belts in vehicles or their use. A proposed law for safety belt use is presented. Public information campaigns could work through radio, television, newspapers and various printed matter and through special events. A list of sources of safety belt material is included.

by Patricia F. Waller; Livia K. Li; B. J. Campbell; Michael L. Herman
University of North Carolina, Hwy. Safety Res. Center, Chapel Hill, N.C. 27514
Contract DOT-HS-6-01520
1977; 134p 29refs
Rept. for 30 Sep 1976-31 May 1977.
Availability: NTIS

HS-802 608

POLICE TRAFFIC SERVICES PERSONNEL PERFORMANCE EVALUATION SYSTEM. FINAL REPORT

The second phase of a two-phase program designed to produce a system for the evaluation of police traffic services (PTS), as performed by a police officer at the patrolman or trooper level, deals with the evaluation concepts, study methodology, and pilot test results. The approach to system development involved four tasks: review of PTS, training, and evaluation literature; collection, analysis, and synthesis of information on PTS operations and training from police agencies; development of preceding information into job descriptions of traffic services as performed at the patrolman level; and identification and definition of factors in the job description for evaluation. Universally acceptable definitions for five PTS functions were derived in terms of actual job performance: traffic law enforcement, accident scene management and investigation, traffic direction and control, court system interaction, and highway service and assistance. Job descriptions define duties and tasks and include an analysis of each duty and task relative to five parameters that affect its potential use as a factor for evaluation. The five parameters are products of the duty or task, observability of the activity, training emphasis typically given to the activity, and gradations of performance that might be established for the activity. The study plan for the second phase encompassed the identification and definition of evaluation factors, the design of forms and instructions for using the factors, pilot testing of the system, and revision if required. The concept of an evaluation system for just PTS was acceptable to most of the supervisors; A common problem, however, was that the supervisors had trouble understanding how the system works and exactly what they were to do. The most frequent criticism was of the manual for lack of clarity, and for being lengthy and repetitious. Although there is only limited statistical evidence of validity, the general response of the participants was that the system is a valid indication of PTS performance. Nonetheless, there was reluctance to adopt the system because of the paperwork involved. It is recommended that the National Hwy. Traffic Safety Administration put the system in the hands of potential users and provide the necessary indoctrination. Appendices contain the pilot test memorandum to participating agencies, a summary of pilot test results, and PTS personnel performance evaluation system forms.

by E. W. Bishop; J. W. Hamilton; J. F. Oates, Jr.
Dunlap and Associates, Inc., 1 Parkland Drive, Darien, Conn. 06820
Contract DOT-HS-6-01386
Rept. No. ED-77-7; 1977; 84p
Rept. for Jun 1976-Jun 1977.
Availability: NTIS

HS-802 613

KANSAS CITY ALCOHOL SAFETY ACTION PROJECT. ROADSIDE SURVEY

In 1971, the Kansas City, Mo., Alcohol Safety Action Project (ASAP) conducted a roadside survey to determine whether or not there had been a significant removal of drinking drivers from the road due to action and activities of ASAP. Some 1127 motorists were stopped at random within city limits for a 30-night period, and were offered the opportunity to voluntarily give a breath sample to be analyzed for alcohol. Questions

were asked which supplied demographic data and information on recent drinking behavior. Of all vehicles stopped, 88.3% overall cooperation was obtained, with 986 tests for blood alcohol concentration (BAC) completed. About 29.6% of drivers stopped had been drinking, and 5.3% had been drinking heavily (BAC of 0.10% or more). Kansas City apparently has a markedly higher amount of drinking and driving than any of five other regions recently surveyed. Percentage of drivers who have been drinking increases from 18.2% between 7 P.M. and 9 P.M. to 42.5% between 1 A.M. and 3 A.M. Percentage of drinking drivers increases from 25.3% on week nights to 33.2% on weekends. Little site-to-site variation was observed. Beer drinkers are more likely to be drinking drivers than those who prefer liquor, or wine. Drunk drivers may be of almost any age, and most drink away from home. Not enough people know what the presumptive BAC limit for intoxication is in order to determine whether such knowledge would influence the incidence of drinking driving. About 39.5% of motorists stopped claimed to have heard of the survey. Six appendices include survey materials, raw data, and data analysis.

by William D. Glauz; George A. Beitel; Michael C. Sharp
Midwest Res. Inst., 425 Volker Blvd., Kansas City, Mo. 64110
Contract DOT-HS-077-1-100
Rept. No. MRI-1; 1972; 69p 4refs
Availability: Reference copy only

HS-802 614

KANSAS CITY ALCOHOL SAFETY ACTION PROJECT. RECOVERING ALCOHOLIC SURVEY. FINAL REPORT

A study has been conducted to determine what the recovering alcoholic could contribute in structuring and evaluating the Kansas City, Mo., Alcohol Safety Action Program (ASAP). Recovering alcoholics who were members of Alcoholics Anonymous (AA) groups were surveyed, with 874 questionnaire responses, and 100 individuals were interviewed in depth. Most respondents did not know their state's presumptive limit blood alcohol content (BAC). Regarding driving after drinking, 51% drove three or more times a week. Of the 439 respondents (51.5%) that were stopped for DWI (driving while intoxicated), 67.2% were booked at the station and 36.8% were ticketed only. Regarding exposure to chemical testing for alcohol, 40% took breath tests, 5% blood tests, and 11% refused tests. Of those arrested for DWI, 66% were convicted as charged, 20% were convicted on a lesser charge, and 14% were acquitted. When asked for opinions on how to help the drinking driver, 44% felt that enforced rehabilitation would not have helped. Some 40% did not know what Antabuse was or had no opinion concerning it. Suggestions for dealing with drinking drivers implied tougher license revocation and fines. Over 60% of those arrested felt that police treated them fairly. Arrests did not affect drinking habits of 51% of respondents. Most alcoholics contacted AA or friends for help. Nine comparative relationships were examined for significance, such as relative income versus number of sober years, and state residence versus knowledge of legal BAC. Respondents tended to hire lawyers more often for second to fourth convictions. Lawyers were often effective in getting the DWI reduced to a lesser charge. Appendices present raw data and the survey instrument.

by William B. House
National Council on Alcoholism, Kansas City Area, Inc.
Contract DOT-HS-077-1-100
1972; 126p
Availability: Reference copy only

HS-802 615

KANSAS CITY ALCOHOL SAFETY ACTION PROJECT. 1971 HOUSEHOLD OPINION AND ATTITUDE SURVEY. SUMMARY REPORT

by George A. Beitel; Michael C. Sharp; William D. Glauz
Midwest Res. Inst., 425 Volker Blvd., Kansas City, Mo. 64110
Contract DOT-HS-077-1-100
Rept. No. MRI-2; 1972; 17p
For abstract, see HS-802 616.
Availability: Reference copy only

HS-802 616

KANSAS CITY ALCOHOL SAFETY ACTION PROJECT. 1971 HOUSEHOLD OPINION AND ATTITUDE SURVEY

A survey was conducted to establish baseline measures of opinions and attitudes of residents of Kansas City, Mo., toward alcohol and traffic safety. The random interview questionnaire survey was intended to support and evaluate the community relations and education program (part of Kansas City's Alcohol Safety Action Project) by testing general knowledge of the public in the area of drinking and driving, to identify public attitudes toward drinking drivers, to identify areas in which the community education program should concentrate its efforts, and to discover methods with which the public feels the drinking driver should be dealt. The questionnaire used was that furnished by the National Hwy. Traffic Safety Administration, Office of Alcohol Countermeasures to all ASAP sites. Some 359 interviews were completed. Although most people (75.8%) drive, over half (68.1%) drink alcoholic beverages, and nearly one third (31.0%) admit to driving after having drunk alcoholic beverages, there was no indication that they know how much alcohol is required to impair driving ability nor did they know the presumptive limit. The majority believed that social drinkers are the principal menace on the highway. The drunk driver problem seemed not to be very real to most people, suggesting the importance of a public education campaign. Countermeasures receiving the most optimism were the more severe penalties and stricter enforcement. Some 48% said they would not be willing to pay extra taxes in an effort to reduce alcohol-related traffic accidents. No subgroup was found to have a sufficiently distinct set of responses that would suggest channeling of public education efforts toward specific groups. Five appendices present the letter of introduction used, the survey instrument, instructions to interviewers, definitions of drinking driver and demographic subgroups, and tabulated responses.

by George A. Beitel; Michael C. Sharp; William D. Glauz
Midwest Res. Inst., 425 Volker Blvd., Kansas City, Mo. 64110
Contract DOT-HS-077-1-100
Rept. No. MRI-2; 1972; 54p
Summary rept. is HS-802 615.
Availability: Reference copy only

HS-802 617

KANSAS CITY ALCOHOL SAFETY ACTION PROJECT. ANALYSIS OF DUI CASES HANDLED BY KANSAS CITY MUNICIPAL COURT DURING 1971

Manual search of Kansas City's Municipal Court journals for 1971 was made for a statistical evaluation of the final disposi-

tions of cases of driving under the influence (DUI) of alcohol. Disposition of 962 cases were obtained. An estimated 89% of arrested drivers were Missouri residents. At the time of arrest, 21.6% did not have a driver's license in their possession. Some 25% had one or more previous DUI convictions on their records, and 33% had had licenses suspended or revoked at some time prior to their present arrest. An average of two continuances was obtained before the case was heard. Once in court, 38.6% pled guilty to DUI, 39.1% pled not guilty, and the DUI charge was nol-prossed 22.3% of the time. Only 7.8% of all cases did not result in a conviction on some charge, and only 2.5% of all cases were appealed to circuit court. The probability of being judged guilty of DUI varied from 40% to 75% from one judge to another, but there was no significant difference between judges on the percent dismissed or acquitted. The typical sentence was either a $100 fine or a 60-day jail sentence with probation ordered (a one-year average probation term). The size of the sentence was essentially unrelated to the plea, although there was a slight tendency by all judges to give a fine only if the plea was guilty to DUI, and a fine plus days if judged guilty of DUI following a nonguilty plea. There was no evidence that any judge was more harsh (or lenient) than another.

by George A. Beitel; William D. Glauz
Midwest Res. Inst., 425 Volker Blvd., Kansas City, Mo. 64110
Contract DOT-HS-077-1-100
Rept. No. MRI-SR-4; 1972; 14p
Availability: Reference copy only

HS-802 618

SEATTLE/KING COUNTY ALCOHOL SAFETY ACTION PROJECT. ANNUAL REPORT: JANUARY-DECEMBER 1971

The Seattle/King County, Wash., Alcohol Safety Action Project (ASAP) activities for 1971 included increased selective enforcement or apprehension, administrative assistance to the courts, and aid in determining disposition of the offender through a presentence investigation. The presentence investigation could lead to an innovative rehabilitation program as an alternative to jail. ASAP work also includes a public education and information campaign to alter public attitudes to drinking and driving. Apprehensions for driving while intoxicated (DWI) increased by 58% during 1971; 23% of those were by the "emphasis patrols." The King County Police made traffic one of its functional units. Convictions for DWI have increased by 8%. Problems with the referrals to rehabilitation of the presentence investigation program are that there are insufficient public treatment facilities and that judges hesitate to refer an employed person to an in-patient program. Driver applicants were given written educational material. A driver improvement program consists of interviewing and assigning license restrictions, probation, or surveillance to small groups of drivers with an alcohol-related incident in their driver file. A rehabilitation program for problem drinkers who drive is suspension of a six-month sentence if the person spends one month in an open-door penal facility (PDD/CRASH) followed by five months of weekly probation meetings with the CRASH staff; an educational program is given the participants. The public information campaign in the media has been well received, and the project has been given favorable media coverage. Use of an advertising agency should be considered. Future plans are given. Community descriptors are presented in tables and graphs.

State of Washington Dept. of Motor Vehicles, Highways-Licenses Bldg., Olympia, Wash. 98504
Contract FH-11-7539
1972; 359p
Availability: Reference copy only

HS-802 619

SEATTLE/KING COUNTY ALCOHOL SAFETY ACTION PROJECT. ANNUAL REPORT: JANUARY-DECEMBER 1972

The Seattle/King County, Wash., Alcohol Safety Action Project (ASAP) activities for 1972 are reviewed month by month, noting progress, problems, changes, and expenses for its activities of increased selective enforcement, presentence screening, driver improvement, driver licensing, and public information and education. A major publicity campaign was kicked off by Dana Andrews who made an impressive whirlwind promotional tour on behalf of ASAP; he emphasized the need for rehabilitation programs. A judicial seminar was held in August to educate judges concerning alcohol safety and to gain their cooperation with the local program. A simulated booking of a drunk driver suspect was staged for an audience including the Secretary of Transportation; media coverage was widespread. A seminar was held for presentence investigators of ASAP in Oct. In Nov a "drink-in" demonstration was highly successful in gaining public interest and in increasing the public's understanding of the effects of alcohol on driving skills; media coverage of the event was excellent. The director of The Problem Drinker Driver/Court Referred Action for Safer Highways (PDD/CRASH) rehabilitation program presented a paper about the program at the Nov meeting of the American Public Health Assoc. Household surveys were conducted in Dec to test for knowledge of the ASAP program. The second and third roadside surveys were conducted in Jun and Dec respectively to gather blood alcohol level (BAC) data and data on patterns of the hours of drinking. Project "Emphasis: Survival" was conducted from 22 Dec 1972-2 Jan 1973 to strictly enforce all traffic violations but especially to apprehend drunk drivers. There has developed a much more favorable attitude toward ASAP characterized by cooperation and participation. Traffic fatalities and alcohol related fatalities are reduced in number, while arrests for driving while intoxicated (DWI) are increased; average BAC of drivers has also dropped. It has proven impractical to use volunteer troopers for the increased emphasis squad since their free time is limited. There was a chain-of-command problem within the county police department. Court overtime was a problem for the Seattle Police Dept. The Seattle Municipal Court has been unwilling to refer first offenders to the presentence investigation office; the Roxbury District Court has refused to refer anyone. Rapid personnel turnover has been a problem, as has access to police records. Approval of public information materials needs to be decentralized, as does approval for minor contract amendments. All administrative and program expenses were slightly below budget with the exception of the Seattle Police Dept.

State of Washington Dept. of Motor Vehicles, Highways-Licenses Bldg., Olympia, Wash. 98504
Contract FH-11-7539
1973; 280p
Availability: Reference copy only

HS-802 620

SEATTLE/KING COUNTY ALCOHOL SAFETY ACTION PROJECT. FINAL REPORT

The Seattle/King County, Wash., Alcohol Safety Action Project (ASAP) appears to have been effective in its activities of increased selective enforcement, presentence screening of those convicted of driving while intoxicated (DWI), driver improvement, driver licensing, and public information and education. Household surveys showed that the majority of the population knew of ASAP and its goals. Roadside surveys showed that there has been a reduction in the percentage of DWI's and in the number of traffic fatalities. However, traffic fatalities increased following the "Project: Survival" patrols at the end of Mar 1973. Most of the courts became advocates of the presentence investigation of convicted DWI's; some have attempted to continue the system since ASAP disbanded. The startling drop in alcohol involvement over the years is shown by the following figures of alcohol-related traffic fatalities: 1970 (pre-ASAP): 52%; 1971, 39%; 1972, 34%; national average, 52%. Arrests of DWI suspects increased monthly; the police officers developed their detection and apprehension techniques as well as a sense of pride in the improved handling of DWI cases in the courts. ASAP-sponsored legislative bills to make it illegal to drive a motor vehicle in Washington with a blood alcohol level of .10 or higher and to allow judiciary discretion in first offenses died in committee in 1973. Two films were produced: one illustrates the development of the problem drinker, and the other portrays what happens to a DWI from the time of arrest through to placement in a rehabilitation program. All major problems of the ASAP project were due to poor communications. Problems are outlined that were specific to the Washington State Patrol, the King County Police Dept., the Seattle Police Dept., the courts, the presentence investigation program, the Problem Drinker Driver/Court Referred Action for Safer Highways (PDD/CRASH) program, driver improvement and public education and information programs, comprehensive treatment efforts, and contract modifications. As for expenditures, all budget calculations remained within the acceptable plus or minus 10%, with the exception of the court overtime programmed for the Seattle Police Dept. The ASAP project has had a striking impact: individuals are aware of and support the program, the police are emphasizing apprehension of drunk drivers, most courts are making referrals to the presentence unit, and judges are helping to expand the presentence and probation aspects of the program. In addition, the county established a traffic division in its Dept. of Public Safety, and DWI arrests have remained high. ASAP arranged for the funding of an Alcohol Information School which had been in danger of closing. In general, the apathy and disinterest in drunk driving has been turned around.

State of Washington Dept. of Motor Vehicles, Highways-Licenses Bldg., Olympia, Wash. 98504
Contract FH-11-7539
1973; 194p 10refs
Rept. for 1 Jul 1970-30 Sep 1973.
Availability: Reference copy only

HS-802 621

COUNTY OF LOS ANGELES ALCOHOL SAFETY ACTION PROJECT. ROADSIDE SURVEY - 1975

The fourth and final roadside survey of the Los Angeles County, Calif., Alcohol Safety Action Project (ASAP) was made 18-19 and 27-28 Sep 1975 (Thursday, Friday, Saturday, and Sunday nights) to gather drinking/driver data and to assess ASAP's educational and law enforcement impact. Of the 1020 drivers systematically sampled from three selected areas, 980 completed the survey and interview and gave breath samples. The nighttime drinking driver, compared with the nighttime driving population as a whole, tended to be older, Mexican-American, and widowed or divorced. Females were less likely to drive after drinking too much; young adults (under 30 years old) were more likely. The Mexican-American and the young adult populations tended to be more influenced by police on the alert for drinking drivers. Only 3% could name ASAP as the sponsor of the campaign to reduce the number of alcohol-related traffic crashes. Of the sample, 24% had been drinking and had a blood alcohol content (BAC) of more than .01; 3% were driving under the influence (BAC greater than .10). Saturday evening (1 A.M.--7 A.M. Sunday morning) was the highest drinking/driving period: one of three drivers was found to have been drinking and one of thirteen under the influence. Separated and divorced drivers were more likely to have positive blood alcohol levels at the time of the survey. The survey plan and instruments are presented in appendices.

by John McIntire
Los Angeles County Alcohol Safety Action Proj., 311 S. Spring St., Los Angeles, Calif. 90013
Contract DOT-HS-161-2-252
1976; 93p
Prepared in cooperation with Health Sciences Computing Facility, Univ. of California, Los Angeles, Grant NIH-RR-3.
Availability: Reference copy only

HS-802 622

WASHTENAW COUNTY BAC [BLOOD ALCOHOL CONTENT] ROADSIDE SURVEY

A roadside survey of drivers conducted as part of the evaluation procedures for the Washtenaw County, Mich., Alcohol Safety Action Program (WCASAP) was designed to obtain a representative sample of Washtenaw County residents and to obtain data about their drinking and driving patterns. Forty-eight time/location cells were defined throughout the county based on time of night, day of week, traffic volume, and location. Drivers were sampled from 7 P.M. to 9 P.M., 10 P.M. to 12 P.M., and from 1 A.M. to 3 A.M. on each of four nights for four consecutive weeks. The survey consisted of collection of a breath specimen for determination of blood alcohol concentration (BAC) and a short on-site interview with the driver. The interview obtained data about the driver's general drinking habits, drinking on the day of the survey, and the specific nature of drinking episodes prior to the time of the interview. Survey sample size was 748. The highest proportions of drinking drivers were found during early morning hours on less heavily traveled roads. Weekday evenings did not differ significantly from weekend evenings. Female drivers and drivers under age 21 were underrepresented. Countermeasures aimed at reducing alcohol-related crashes should emphasize the 21-25 age group. Divorced and separated persons were over-involved in drinking and driving; however, distribution of persons with positive BAC's was similar among educational and occupational categories. Many respondents expressed various levels of awareness of WCASAP. Significant overall findings were that 19% of the drivers tested had a positive BAC, 10% were at a BAC of 0.05 or higher, 4% were 0.10 or higher, and 1%

were 0.15 or higher. Six appendices present survey instruments and data, as well as data analysis.

by William L. Carlson; Marion M. Chapman; Cheryl D. Clark; Lyle D. Filkins; Arthur C. Wolfe
University of Michigan, Hwy. Safety Res. Inst., Huron Pkwy. and Baxter Rd., Ann Arbor, Mich. 48105
Contract FH-11-7535
Rept. No. HSRI-71-126; 1971; 83p 3refs
Rept. for 1 Jul 1970-30 Jun 1971.
Availability: Reference copy only

HS-802 623

WASHTENAW COUNTY, MICHIGAN ALCOHOL SAFETY ACTION PROGRAM. ANNUAL REPORT, FY-1973

An annual report on Washtenaw County, Mich., Alcohol Safety Action Project (WCASAP) details efforts in 1972 to reduce driving under the influence of liquor (DUIL) and driving while intoxicated (DWI). Total number of alcohol related arrests increased from 846 in 1971 to 1854 in 1972. The Antabuse case load increased from 300 in Jan to 396 in Dec. Total number of referrals to the Alcohol Education Series (AES) and the Educational Program for Probationers (EPP) increased from 242 to 319. Total number of clients placed on probation in the ASAP increased from 462 to 734 clients. The documentary film entitled "Guilty Victim" was completed. There were 468 referrals made to the County Driver Education School during the year from district courts and the Secretary of State's office. The Antabuse program was changed to monitored administration, extension to seven weeks of classes, a faster result reporting system to probation officers, and more client contact for group discussion. Significant increases were made in materials placed in the mass media and presented through the speakers' bureau and film library. Problems in the Antabuse program relate to probationers substituting other kinds of pills. Cumulative expenditures from 1 Aug 1970 to Dec 1972 total $1,268,386.

by James Henderson
Washtenaw County, Michigan, Alcohol Safety Action Program, Ann Arbor, Mich.
Contract FH-11-7535
1973; 47p
Rept. for 1 Jan-31 Dec 1972.
Availability: Reference copy only

HS-802 624

COUNTY OF LOS ANGELES ALCOHOL SAFETY ACTION PROJECT. PRELIMINARY ANALYSIS OF THE IMPACT OF ASAP ON THE TRAFFIC SAFETY SYSTEM. ANALYTIC STUDY FOR 1975

Two samples of persons driving under the influence (DUI's), arrested in Jan 1972 and Jan 1973, are tracked and compared to show impact of the Los Angeles, Calif., County Alcohol Safety Action Project (ASAP). In the area of law enforcement, it is seen that DUI arrests increased significantly in 1973, particularly in areas patrolled by ASAP officers. As for judicial matters, there were significant increases in proportion of total convictions with fewer pleadowns and dismissals and in the proportion of DUI convictions to total convictions. Sentences showed a greater relationship to blood alcohol level (BAC) evidence, partly due to ASAP educational efforts and to use of ASAP-funded breath testing equipment by arrest agencies. More than half of the 1973 cases received an ASAP presentence or postsentence investigation; judges showed a high level of agreement with ASAP treatment recommendations. Forty problem drinkers were identified in a sample of 207. The number of treatment referrals doubled. Judges modified use of traditional sanctions in ways which facilitated DUI participation in ASAP. In one of the three mini-ASAP courts, case processing time increased significantly due to a loss of judicial personnel and the lengthy presentence investigations procedures. As for rehabilitation, the number of persons actually entering treatment rose significantly, and a wider range of treatment modalities was utilized for referrals. A study of recidivism showed that a nonsignificant drop in recidivism occurred for the total 1973 sample. A statistically significant reduction occurred, however, in the mini-ASAP court which had the highest retreatment referral rate. ASAP problems during the year included the low rate of participation by one of the courts in the presentence investigation program and a lack of sufficient data about DUI movements through treatment programs. Information presented in appendices includes ASAP reimbursed costs, breakdown of California Vehicle Code sanctions for DUI and reckless driving in 1972 and 1973, study methodology, data analyses for total 1972 and 1973 samples, and data analyses for each mini-ASAP court.

by Julie A. Croke
Los Angeles County Alcohol Safety Action Proj., Los Angeles, Calif.
Contract DOT-HS-161-2-252; Grant NIH-RR-3
1974; 137p
Availability: Reference copy only

HS-802 625

COUNTY OF LOS ANGELES ALCOHOL SAFETY ACTION PROJECT. AN ANALYSIS OF ULTIMATE PERFORMANCE MEASURES: 1974

The Los Angeles County, Calif., Alcohol Safety Action Project (ASAP) activities during 1974 included law enforcement, judicial, rehabilitation, licensing, legislative, and public information activities in an eastern portion of the county which are assessed by comparison with the South Bay area as a control. Law enforcement activities included increased DUI arrests of 196% for sheriff patrols and 691% for Covina patrols. Of those arrested, 97% were convicted. The most effective rehabilitation measure was that of Alcoholics Anonymous combined with motivational counseling. Of 683 persons classified as problem drivers, 26% were referred to ASAP. Legislation concerning drinking and driving considered included use of preliminary breath screening devices, standardization of court school operations, and defraying presentence and postsentence costs. A countywide, multimedia, public service campaign was begun in the latter half of 1974. Of the 11 crash measures used to compare the ASAP area with the control area, only one measure - single vehicle crashes - gave evidence that there was a statistically significant difference in the two areas for the operational period. The evidence was contrary to expectations: there was a lower average number of crashes in the control area than in the ASAP area. This measure may not be a valid indicator of ASAP effectiveness. Profiles are made of fatally injured drivers, persons arrested on DUI charges, and of a group of average nighttime drivers as to their BAC levels. A DUI arrestee was more likely to have a high BAC the more prior such arrests he had; arrestees with high BAC levels were less likely to be involved in accidents than persons with lower

BAC levels. ASAP is considered effective because of increased arrest rates, early detection and treatment of problem drinkers, and because it is a model of such detection and of presentence investigation procedures. Information in appendices includes a flowchart of ASAP activities, crash data and statistics, and basic data of the crash measures.

by Ronald M. Florendo
Los Angeles County Alcohol Safety Action Proj., Los Angeles, Calif.
Contract DOT-HS-161-2-252; Grant NIH-RR-3
1975; 115p
Availability: Reference copy only

HS-802 626

LOS ANGELES COUNTY ALCOHOL SAFETY ACTION PROJECT. 1974 ANNUAL REPORT

The Los Angeles County, Calif., Alcohol Safety Action Project (ASAP), during its second full year of operations, employed 95 persons directly and another 39,374 volunteer hours were given at no cost to the project. Regarding law enforcement countermeasures, number of driving under the influence (DUI) arrests increased over 4% from 1973. Arrests among regular law enforcement units decreased slightly (3%) while arrests for ASAP units increased 43% over 1973. The gas chromatograph intoximeter enabled officers to conduct better investigations, but video tape recording was not cost effective for use in court. The total conviction rate remained as high as in 1973. The proportion convicted of lesser offenses (pleadowns) increased significantly. Courts increased utilization of ASAP DUI presentence investigation by 70.9%. Identification of problem drinkers through the presentence investigation process remains high. The number of DUI offenders entering rehabilitation programs was up 20% over the previous year. The licensing countermeasure, operating in two Div. of Motor Vehicle offices, reviewed 11,324 cases and identified 683 drivers as possible problem drinkers. The Legislative Workshop established under the auspices of ASAP continued through 1974 to serve as a stimulus toward improved legislation in alcohol traffic safety. Three TV and seven radio public service announcements were produced which received audience endorsement and critical acclaim. Coordinated efforts in 1974 for ASAP activities have had considerable impact on the traffic safety system from arrest through adjudication to rehabilitation. Fatal accidents have been reduced 27%, attributed to saturation of ASAP patrol units per area.

Los Angeles County Alcohol Safety Action Proj., 311 South Spring St., Suite 700, Los Angeles, Calif. 90012
Contract DOT-HS-161-2-252
1974; 66p
Availability: Reference copy only

HS-802 627

PUERTO RICO ASAP [ALCOHOL SAFETY ACTION PROJECT]. FINAL REPORT

Activities of the Puerto Rico Alcohol Safety Action Project (ASAP) began in Jul 1972 with Special Alcohol Patrol Units, educational presentations and media spots in Sep 1972, and pretrial recidivism investigations of driving while intoxicated (DWI) cases early in 1973. The project was not fully operational, however, until legislation was passed in May 1973 (effective Jul 1973) which required presentence investigation of all convicted DWI offenders, eliminated urinalysis as a method of testing blood alcohol content (BAC), and established a Dept. of Addiction Services to provide rehabilitation for the problem drinker. A patrol was set up to remove drunk pedestrians from a particular section of road, in order to reduce pedestrian fatalities. Problems encountered by ASAP included a backlog of court cases due to the great increase in DWI arrests, confusion concerning the new laws, and skepticism of breath testing of BAC. A series of seminars on ASAP offered to judges, prosecutors, probation officers, and rehabilitation personnel helped allay doubts and skepticism. Legislation effective Jul 1976 lowered the presumptive BAC limit from .15 to .10. To help reduce the backlog of presentence investigations, use of the Mortimer-Filkins questionnaire (translated into Spanish) was initiated. Some DWI cases were transferred from the Superior Courts to the District Courts to help reduce the case backlog. All programs except that of the DWI prosecutors were felt to have met their objectives. DWI arrests increased to 8000 in 1974 and possibly 10,000 in 1975 from a baseline of 1300. Pedestrian fatalities in the area of the special pedestrian patrol were reduced 48.5%. Of BAC testing in DWI cases, 70% was breath testing. Conviction rate dropped from 71% to 64% because of the court backlog. Educators made 1949 presentations to a total audience of 68,198; DWI improvement courses were offered to 3478 social drinkers. A total of 5970 presentence investigations were made, identifying 2106 problem drinkers. By the close of the project in Jun 1975, 123 problem drinkers had completed rehabilitation and 1449 were still under treatment in alcoholism centers. The public information campaign used national rather than local materials until early in 1975. Household and roadside surveys showed no significant increase of awareness of ASAP by the general public. Although total fatal crashes increased 4% during the ASAP period from the baseline period, there was a decrease in fatal crashes involving heavy alcohol use (from 315 to 244). Studies of the four household and four roadside surveys are appended.

Puerto Rico Traffic Safety Commission, Puerto Rico Alcohol Safety Action Proj., P.O. Box FI, Santurce, Puerto Rico 00910
Contract DOT-HS-160-2-251
Rept. No. PRTSC-75-1; 1975; 102p
Rept. for Jul 1972-Jun 1975.
Availability: Reference copy only

HS-802 629

RESPONSE OF BELTED DUMMY AND CADAVER TO REAR IMPACT. FINAL REPORT

Sled tests were performed to compare the dynamic responses of seated and belted unembalmed cadavers with that of similarly seated and belted 50th percentile Part 572 anthropomorphic dummies (having both regular and Itoh necks), and to study the type and severity of injuries, especially in respect to the head-neck complex, that may occur to the cadavers. Sled impacts at 16 mph simulated the motion of a standard size car at rest impacted from the rear by a second car of equal weight traveling at 32 mph. Comparison of cadaver and dummy performances was made by computing the head axial force, shear force, and torque at the occipital condyles according to the Mertz-Patrick methodology. The effectiveness of a deflecting seatback versus a rigid seatback in reducing injury was compared. Extrapolation was made of the degree of observed injury to equivalent degree of injury expected with in vivo subjects. A total of 17 sled impacts were

mode, between dummy and cadaver was that the dummy head oscillated while the cadaver head did not. Although the head severity indices for both cadaver and dummy have similar maximum values, the values for the dummy responses under the deflecting and the rigid seatback configurations shows that, except for the first thoracic vertebra's angular acceleration, all the maximum values of chest parameters in the deflecting seatback case are lower than those of the rigid seatback case; also, responses under the rigid seatback configuration have shorter duration and occur earlier than those under the deflecting seatback configuration. All three cadavers tested with a deflecting seatback suffered neck injuries as high as Abbreviated Injury Scale (AIS) 3, while two of the three cadavers suffered similar injuries with a rigid seatback. The third cadaver tested with a rigid seatback had no injury. The tests do not provide an adequate sampling for firm conclusions; further testing should use a straightforward device to measure kinematic responses. Appended are electronic sensor, photographic, statistical, and autopsy data; as well as information on the digital computer program, the pulse-code-modulation instrumentation system, seatback modifications, an electromagnetic test subject restraining device, and other studies of three-dimensional kinematic model.

by A. S. Hu; S. P. Bean; R. M. Zimmerman
New Mexico State Univ., Physical Science Lab., P.O. Box 3548, Las Cruces, N. Mex.
Contract DOT-HS-5-01201
Rept. No. PR00848; 1976; 441p refs
Availability: Reference copy only

HS-802 632

FMVSS 301-75 STANDARDS ENFORCEMENT TESTING OF FUEL SYSTEM INTEGRITY - NHTSA NO. 76406. FINAL REPORT

A 1976 American Motors Corp. Gremlin two-door sedan was crash tested to determine its compliance with Federal Motor Vehicle Safety Standard (FMVSS) 301-75, fuel system integrity for passenger cars. A perpendicular frontal impact was made into a fixed barrier at a speed of 29.4 mph; a steel follower shoe riding on the monorail guided the vehicle to the barrier, detaching just prior to impact. Since there was no fuel spillage during barrier impact, during the specified period after impact, or during the vehicle rollover test sequence, the vehicle appeared to comply with the FMVSS standards. Photos, calcomp plots, and descriptions of test facilities, equipment, and procedure are presented.

Ultrasystems, Inc., Dynamic Science Div., 1850 W. Pinnacle Peak Rd., Phoenix, Ariz. 85027
Contract DOT-HS-6-01360
Rept. No. 301-DYS-76-001; 1976; 68p
Availability: Reference copy only

A 1976 Volkswagen Rabbit two-door sedan was crash tested to determine compliance with Federal Motor Vehicle Safety Standard (FMVSS) 301-75 regarding fuel spillage from the vehicle fuel system. The vehicle was subjected to a perpendicular frontal impact speed of 30 mph. A steel follower shoe riding on a 1200-foot monorail guided the vehicle to the fixed collision barrier, detaching from the vehicle just prior to impact. Propulsion was provided by two 390 cu in V-8 engines in tandem driving an endless cable tow system through a modified automatic transmission. An onboard abort system consisted of a remote, gas actuated, brake machine installed in the brake line. Measured impact speed was 29.4 mph. No fuel system fluid loss was observed during or after the crash, nor during the rollover test, indicating vehicle compliance with FMVSS 301-75. Test procedures and check lists are included. An addendum report is made on a test conducted to obtain data on front occupant response and vehicle acceleration during impact into a fixed collision barrier at 28.3 mph. Dummy head acceleration data are processed as class 1000 data, combined to form the resultant and integrated to give velocities and displacement. Dummy chest accelerations and femur loads are processed as class 180 and class 600 data, respectively. Appendices present test photographs and calcomp plots.

Ultrasystems, Inc., Dynamic Science Div., 1850 W. Pinnacle Peak Rd., Phoenix, Ariz. 85027
Contract DOT-HS-6-01360
Rept. No. 301-DYS-76-002; 1976; 69p
Availability: Reference copy only

HS-802 634

FMVSS 301-75 STANDARDS ENFORCEMENT TESTING OF FUEL SYSTEM INTEGRITY - NHTSA 76117. FINAL REPORT

A 1976 Chevrolet Impala two-door sedan was crash-tested to determine compliance with Federal Motor Vehicle Safety Standard (FMVSS) 301-75 regarding fuel spillage from the vehicle fuel system. The vehicle was subjected to a perpendicular frontal impact speed of 30 mph. A steel follower shoe riding on a 1200-foot monorail guided the vehicle to the fixed collision barrier, detaching from the vehicle just prior to impact. Propulsion was provided by two 390 cu in V-8 engines in tandem driving an endless cable tow system through a modified automatic transmission. An onboard abort system consists of a remote, gas actuated, brake machine installed in the brake line. Measured impact speed was 29.2 mph. No fuel system fluid loss was observed during or after the crash, nor during the rollover test, indicating vehicle compliance with FMVSS 301-75. Test procedures and check lists are included. An addendum report is made on a test conducted to obtain data on front occupant response and vehicle acceleration during impact into a fixed collision barrier at 29.2 mph. Dummy head acceleration data are processed as class 1000 data, combined to form the resultant and integrated to give velocities and displacement. Dummy chest accelerations and femur loads

are processed as class 180 and class 600 data, respectively. Appendices present test photographs and calcomp plots.

Ultrasystems, Inc., Dynamic Science Div., 1850 W. Pinnacle Peak Rd., Phoenix, Ariz. 85027
Contract DOT-HS-6-01360
Rept. No. 301-DYS-76-003; 1976; 65p
Availability: Reference copy only

HS-802 635

FMVSS 301-75 STANDARDS ENFORCEMENT TESTING OF FUEL SYSTEM INTEGRITY - NHTSA 76118. FINAL REPORT

A 1976 Chevrolet Nova two-door sedan was crash tested to determine compliance with Federal Motor Vehicle Safety Standard (FMVSS) 301-75 regarding fuel spillage from the vehicle fuel system. The vehicle was subjected to a perpendicular frontal impact speed of 30 mph. A steel follower shoe riding on a 1200-foot monorail guided the vehicle to the fixed collision barrier, detaching from the vehicle just prior to impact. Propulsion was provided by two 390 cu in V-8 engines in tandem driving an endless cable tow system through a modified automatic transmission. An onboard abort system consisted of a remote, gas actuated, brake machine installed in the brake line. Measured impact speed was 29.1 mph. No fuel system fluid loss was observed during or after the crash, nor during the rollover test, indicating vehicle compliance with FMVSS 301-75. Test procedures and check lists are included. An addendum report is made on a test conducted to obtain data on front occupant response and vehicle acceleration during impact into a fixed collision barrier at 29.1 mph. Dummy head acceleration data are processed as class 1000 data, combined to form the resultant and integrated to give velocities and displacement. Dummy chest accelerations and femur loads are processed as class 180 and class 600 data, respectively. Appendices present test photographs and calcomp plots.

Ultrasystems, Inc., Dynamic Science Div., 1850 W. Pinnacle Peak Rd., Phoenix, Ariz. 85027
Contract DOT-HS-6-01360
Rept. No. 301-DYS-76-004; 1976; 66p
Availability: Reference copy only

HS-802 636

FMVSS 301-75 STANDARDS ENFORCEMENT TESTING OF FUEL SYSTEM INTEGRITY - NHTSA 76119. FINAL REPORT

A 1976 Chevrolet Vega two-door sedan was crash-tested to determine compliance with Federal Motor Vehicle Ssafety Standard (FMVSS) 301-75 regarding fuel spillage from the vehicle fuel system. The vehicle was subjected to a perpendicular frontal impact into a fixed collision barrier at an impact speed of 30 mph. A steel follower shoe riding on a monorail guided the vehicle to the fixed collision barrier, detaching from the vehicle just prior to impact. Measured test impact speed was 29.2 mph. There was some fuel system fluid loss after the barrier crash and during the rollover test. Total fuel loss or rates of fluid loss did not exceed requirements for designated time periods specified in FMVSS 301-75. Test procedures and check lists are included. An addendum report is made on a test conducted to obtain data on front occupant response and vehicle acceleration during impact into a fixed collision barrier at 29.2 mph. Dummy head acceleration data are processed as class 1000 data, combined to form the resultant and integrated to give velocities and displacement. Dummy chest accelerations and femur loads are processed as class 180 and class 600 data, respectively. Appendices present data photographs and calcomp plots.

Ultrasystems, Inc., Dynamic Science Div., 1850 W. Pinnacle Peak Rd., Phoenix, Ariz. 85027
Contract DOT-HS-6-01360
Rept. No. 301-DYS-76-005; 1976; 67p
Availability: Reference copy only

HS-802 637

FMVSS 301-75 STANDARDS ENFORCEMENT TESTING OF FUEL SYSTEM INTEGRITY - NHTSA 76216. FINAL REPORT

A Ford Motor Co. Pinto Pony two-door sedan was crash tested to determine compliance with Federal Motor Vehicle Safety Standard (FMVSS) 301-75 regarding fuel spillage from the vehicle fuel system. The vehicle was subjected to a perpendicular frontal impact speed of 30 mph. A steel follower shoe riding on a 1200-foot monorail guided the vehicle to the fixed collision barrier, detaching from the vehicle just prior to impact. Propulsion was provided by two 390 cu in V-8 engines in tandem driving an endless cable tow system through a modified automatic transmission. An onboard abort system consisted of a remote, gas actuated, brake machine installed in the brake line. Measured impact speed was 29.2 mph. The vehicle's fuel system appears not to comply with requirements of FMVSS 301-75. Fuel system fluid loss exceeded five ounces by weight during the five-minute period following cessation of motion after barrier impact. The fuel system fluid loss rate exceeded one ounce by weight per minute during the subsequent ten-minute period. Test procedures and check lists are included. An addendum report is made on a test conducted to obtain data on front occupant response and vehicle acceleration during impact into a fixed collision barrier at 29.2 mph. Dummy head acceleration data are processed as class 1000 data, combined to form the resultant and integrated to give velocities and displacement. Dummy chest accelerations and femur loads are processed as class 180 and class 600 data, respectively. Appendices present test photographs and calcomp (acceleration vs. time) plots.

Ultrasystems, Inc., Dynamic Science Div., 1850 W. Pinnacle Peak Rd., Phoenix, Ariz. 85027
Contract DOT-HS-6-01360
Rept. No. 301-DYS-76-006; UI-3975-76-41; 1976; 73p
Availability: Reference copy only

HS-802 638

FMVSS 301-75 STANDARDS ENFORCEMENT TESTING OF FUEL SYSTEM INTEGRITY - NHTSA 76545. FINAL REPORT

A 1976 Volkswagen Dasher two-door sedan was crash tested to determine compliance with Federal Motor Vehicle Safety Standard (FMVSS) 301-75 regarding fuel spillage from the vehicle fuel system. The vehicle was subjected to a perpendicular frontal impact speed of 30 mph. A steel follower shoe riding on a 1200-foot monorail guided the vehicle to the fixed collision barrier, detaching from the vehicle just prior to impact. Propulsion was provided by two 390 cu in V-8 engines in tandem driving an endless cable tow system through a

pact into a fixed collision barrier at 29.3 mph. Dummy head acceleration data are processed as class 1000 data, combined to form the resultant and integrated to give velocities and displacement. Dummy chest accelerations and femur loads are processed as class 180 and class 600 data, respectively. Appendices present test photographs and calcomp plots.

Ultrasystems, Inc., Dynamic Science Div., 1850 W. Pinnacle Peak Rd., Phoenix, Ariz., 85027
Contract DOT-HS-6-01360
Rept. No. 301-DYS-76-007; 1976; 65p
Availability: Reference copy only

HS-802 639

FMVSS 301-75 STANDARDS ENFORCEMENT TESTING OF FUEL SYSTEM INTEGRITY - NHTSA 76104. FINAL REPORT

A 1976 Chevrolet Chevette two-door hatchback sedan was crash tested to determine compliance with Federal Motor Vehicle Safety Standard (FMVSS) 301-75 regarding fuel spillage from the vehicle fuel system. The vehicle was subjected to a perpendicular frontal impact speed of 30 mph. A steel follower shoe riding on a 1200-foot monorail guided the vehicle to the fixed collision barrier, detaching from the vehicle just prior to impact. Propulsion was provided by two 390 cu in V-8 engines in tandem driving an endless cable tow system through a modified automatic transmission. An onboard abort system consisted of a remote, gas actuated, brake machine installed in the brake line. Measured impact speed was 28.3 mph. No fuel system fluid loss was observed during or after the crash, but slight leakage occurred during the rollover test. The leakage rate was well below the maximum rate allowed by FMVSS 301-75, totaling less than 15 drops. An addendum report is made on a test conducted to obtain data on front occupant response and vehicle acceleration during impact into a fixed collision barrier at 28.3 mph. Dummy head acceleration data are processed as class 1000 data, combined to form the resultant and integrated to give velocities and displacement. Dummy chest accelerations and femur loads are processed as class 180 and class 600 data, respectively. Appendices present test photographs and calcomp plots.

Ultrasystems, Inc., Dynamic Science Div., 1850 W. Pinnacle Peak Rd., Phoenix, Ariz. 85027
Contract DOT-HS-6-01360
Rept. No. 301-DYS-76-008; 1977; 75p
Availability: Reference copy only

HS-802 640

FMVSS 301-75 STANDARDS ENFORCEMENT TESTING ON FUEL SYSTEM INTEGRITY - NHTSA 76134. FINAL REPORT

A 1976 Pontiac Sunbird two-door sedan was crash tested to determine compliance with Federal Motor Vehicle Safety Standard (FMVSS) 301-75 regarding fuel spillage from the brake line. Measured impact speed was 29.5 mph. No fuel system fluid loss was observed during or after the crash; however, there was some leakage during the rollover, although still within the requirements of FMVSS 301-75. There was 1.89 ounces of spillage at the 180° position, 0.86 ounces in the roll from 180° to 270°, and 3.69 ounces at the 270° position. All leakage was from the filler cap. An addendum report is made on a test conducted to obtain data on front occupant response and vehicle acceleration during impact into a fixed collision barrier at 29.5 mph. Dummy head acceleration data are processed as class 1000 data, combined to form the resultant and integrated to give velocities and displacement. Dummy chest accelerations and femur loads are processed as class 180 and class 600 data, respectively. Appendices present test photographs and calcomp plots.

Ultrasystems, Inc., Dynamic Science Div., 1850 W. Pinnacle Peak Rd., Phoenix, Ariz. 85027
Contract DOT-HS-6-01360
Rept. No. 301-DYS-76-009; 1977; 76p
Availability: Reference copy only

HS-802 641

SMALL CAR DRIVER INFLATABLE RESTRAINT SYSTEM EVALUATION. MONTHLY PROGRESS REPORT FOR THE INTERVAL FROM OCTOBER 2, 1976 TO NOVEMBER 2, 1976

The Plymouth Valiant sled test series was accomplished, fabrication of the Vega body buck was completed and pulse-tailoring tests conducted, and fabrication of the Chevette buck was begun. Changes made during the Valiant sled tests of a 50th percentile dummy in 30 mph perpendicular barrier impacts resulted in an increase in the effective mass of the upper body and a reduction in head injury criteria (HIC's) and peak chest g's. In the final test, results were within the proposed limits of Federal Motor Vehicle Safety Standard (FMVSS) 208. Complete data packages are presented in an appendix. Examination of the Chevette during test preparation shows that satisfactory performance in 30 mph tests won't be possible without major changes in the driver station geometry and column support structure; such work would require a contract modification. The recommended work is diagrammed.

Minicars, Inc., 35 La Patera Lane, Goleta, Calif. 93017
Contract DOT-HS-6-01412
Rept. No. PR-(Oct-Nov)-76; 1976; 43p
Availability: Reference copy only

HS-802 642

SMALL CAR DRIVER INFLATABLE RESTRAINT SYSTEM EVALUATION. MONTHLY PROGRESS REPORT FOR THE INTERVAL FROM NOVEMBER 2, 1976 TO DECEMBER 2, 1976

Ten sled tests of the Vega buck were performed, the Chevette test series was begun, and a meeting was held to define future

program work. The Vega tests of 50th percentile dummies in 30 mph perpendicular barrier impacts were unsuccessful in meeting criteria of Federal Motor Vehicle Safety Standard (FMVSS) 208, in spite of various improvements made to the air cushion, column, and seat. The reasons for the failure seem to be that the Vega crash pulse allows very little occupant ridedown and that the General Motors (GM) air cushion retracts to an ellipsoidal shape on the steering wheel, adding to the distance the driver must move before re-engagement of contact with the air bag. The Chevette tests have had encouraging results: the poor driver station geometry noted earlier seemed to be offset by the beneficial aspects of its crash pulse. Program changes to be made as a result of the meeting at the National Hwy. Traffic Safety Administration include continuation of the Chevette tests with an emphasis on determining the relationship between knee restraint proximity and injury measures. In addition, a modified wheel module is to be evolved which will deploy a bag with the potential of engaging the Vega driver earlier than is presently the case. Sled test data traces for both Vega and Chevette tests are appended.

Minicars, Inc., 35 La Patera Lane, Goleta, Calif. 93017
Contract DOT-HS-6-01412
Rept. No. PR-(Nov-Dec)-76; 1976; 51p
Availability: Reference copy only

HS-802 643

SMALL CAR DRIVER INFLATABLE RESTRAINT SYSTEM EVALUATION. MONTHLY PROGRESS REPORT FOR THE INTERVAL FROM JANUARY 2, 1977 TO FEBRUARY 2, 1977

Eleven additional Vega sled tests (Series II tests) were run, during which it was determined that minimum 50th percentile dummy injury measures at 30 mph impact require a 2.24 sq in venting and a 1200 lb column collapse force. Work continued, however, on the inflator and air bag to increase the ridedown potential. Degradation in performance in later tests was due to problems with the column, including structural weakness just off of the turn signal housing, gradual weakening and shifting of the column bracketry, and a subtle geometry change in column orientation which subjected the steering shaft to pre-impact bending stresses. Further testing is postponed until Apr. Data traces are appended.

Minicars, Inc., 35 La Patera Lane, Goleta, Calif. 93017
Contract DOT-HS-6-01412
Rept. No. PR-(Jan-Feb)-77; 1977; 71p
Availability: Reference copy only

HS-802 644

SMALL CAR DRIVER INFLATABLE RESTRAINT SYSTEM EVALUATION. PROGRESS REPORT FOR FEBRUARY 1977

Static column collapse tests were conducted with both standard and modified Vega, Valiant, and Volvo steering columns. In addition, a modified version of the General Motors (GM) energy absorbing (EA) column was conceived and component tests conducted on its redesigned EA unit. ABAG-19 computer simulations were begun; conclusions are not yet available. Results of each test are graphed. Neither the Valiant column nor the Volvo column appears to be suitable as an alternative to the column in the Vega: the EA characteristic of the Valiant column is erratic and does not lend itself to force-level adjustment, and the Volvo column EA jacket had a disturbing mode of failure. A modification of the Vega column has been designed, however, in which the ball jacket and existing steering shaft assembly are replaced by a steering assembly which also serves as an energy absorber. The energy-absorbing mechanism is a spherically shaped mandrel which expands the forward section of the steering linkage. Tests shown that a 0.0285 inch gauge tube would be suitable for a column stroking at 1200 lb.

Minicars, Inc., 35 La Patera Lane, Goleta, Calif. 93017
Contract DOT-HS-6-01412
Rept. No. PR-Feb-77; 1977; 16p
Availability: Reference copy only

HS-802 645

SMALL CAR DRIVER INFLATABLE RESTRAINT SYSTEM EVALUATION. PROGRESS REPORT FOR MARCH 1977

Static column collapse tests were conducted on the modified General Motors (GM) energy-absorbing column to confirm its design collapse load and its sensitivity to rim uploading; the ABAG-19 simulations were terminated; and six additional Vega sled tests were run as well as four Valiant sled tests. The static column collapse tests confirmed that the mandrel/tube energy absorbing unit evolved during February has excellent energy absorbing characteristics. Modified ABAG-19, known as DBAG-2, was run about 45 times to simulate actual sled run data. An acceptable match between actual and simulated data was not possible because the program does not adjust bag penetration to be consistent with column force. It was decided not to continue with the program modifications or the simulations. The Vega sled test results indicate that a driver restraint system for this vehicle has been successfully evolved which incorporates the mandrel/tube modification of the steering column, the enlarged GM bag, and 115 gram Thiokol inflator. The modified steering column was placed in the Valiant; sled tests showed that, with modifications to give additional knee and leg protection, it was successful in meeting the 50th percentile, 30 mph standard of Federal Motor Vehicle Safety Standard (FMVSS) 208. Data traces for both the Vega and Valiant tests are appended.

Minicars, Inc., 35 La Patera Lane, Goleta, Calif. 93017
Contract DOT-HS-6-01412
Rept. No. PR-Mar-77; 1977; 45p
Availability: Reference copy only

HS-802 646

SMALL CAR DRIVER INFLATABLE RESTRAINT SYSTEM EVALUATION. PROGRESS REPORT FOR JUNE 1977

Phase 2 of the contract began, under a verbal contractual agreement only, with four Valiant buck sled tests to evaluate the restraint system evolved for the 50th percentile male driver when used by other driver somatotypes. Results from testing with a 95th percentile male dummy show that it would benefit from less venting. Tests of a 5th percentile female dummy revealed severe abdominal loading from the lower half of the

Availability: Reference copy only

HS-802 647

SMALL CAR DRIVER INFLATABLE RESTRAINT SYSTEM EVALUATION. PROGRESS REPORT FOR JULY 1977

Seven Chevette sled tests were conducted to evolve a driver station geometry that would provide 30 mph protection with a dash modified to give at least four inches of leg clearance. The column was modified to incorporate the tube/mandrel energy absorbing mechanism. The first test gave encouraging results, but in attempting to duplicate those results, knee restraints bottomed out and rips in air bags were found to be caused by a new type of cooling screen. Collapse force of the column needed to be certified at 1200 lb. The new inflators provided as replacements by the supplier had gas flow characteristics sufficiently different from the originals that the good results of the first test could not be duplicated.

Minicars, Inc., 35 La Patera Lane, Goleta, Calif. 93017
Contract DOT-HS-6-01412
Rept. No. PR-Jul-77; 1977; 31p
Availability: Reference copy only

HS-802 648

SMALL CAR DRIVER INFLATABLE RESTRAINT SYSTEM EVALUATION. PROGRESS REPORT FOR AUGUST 1977

Thiokol conducted tank tests to produce an inflator whose flow characteristics approximated those obtained before cooling screens were changed. A 100 gm inflator with an 85/15 grain distribution was selected. Lateral tubing on the Chevette buck was substantially reinforced and Chevette sled tests were restarted with the new inflator. Those tests, complete data traces of which are appended, showed that knee restraints could be improved for the 50th percentile dummy by coring them with styrofoam, the 5th percentile female dummy received some abdominal injury, and for the 95th percentile male dummy the column force can be lowered and the cored knee restraints did not provide suitable protection. The third Vega car crash test was conducted with a 30 mph barrier and two 50th percentile unrestrained dummies; it was intended for use as a baseline. Work continues under verbal agreement only.

Minicars, Inc., 35 La Patera Lane, Goleta, Calif. 93017
Contract DOT-HS-6-01412
Rept. No. PR-Aug-77; 1977; 36p
Availability: Reference copy only

The solid propellant inflation system should, when combined with airbag and knee restraints, protect passengers in subcompact cars at impacts of 45-50 mph within allowable injury criteria, and should be easily convertible to mass production. The Simca C-6 as modified by Calspan for the Research Safety Vehicle (RSV) will be used at impacts up to 50 mph and at impact directions varying from zero to 30°. Injury criteria are listed for femur loads, chest acceleration, head injury, rearward velocity, and displacement; some criteria vary according to the particular dummy involved. The program plan includes study of earlier work done in the field, especially as it concerns the out-of-position child, followed by static testing of potentially suitable airbag and inflator systems using a standard Simca seat and a six-year size child dummy. A particular bag folding technique is to be used which results in only the inflated portion of the bag impacting on the child's chest. Design of the baseline system for sled testing will probably include a dual airbag design which efficiently uses the inflator gas and which provides a blunt profile for passenger restraint. Sled test plans call for 20 tests on a VEAC II decelerative sled beginning with the 50th percentile male dummy and frontal impacts at approximately 40 mph; impact speeds will be increased, then other percentile dummies will be tested. Sled tests on the six-year size dummy out of position will be made on an American Safety Equipment sled. Data will be processed by the new Minicars data reduction system. The task of system performance evaluation is to define the crash survivability envelope of the restraint system developed in the Simca. This envelope is the velocity change in each representative frontal impact accident mode at which the dummy injury measures just reach the allowable injury criteria. Representative impact modes for the sled tests will be the 12 o'clock and 1 o'clock impact direction; the dummies will be in both normal position and out of position. In addition, four vehicle crash tests will be performed. The spending schedule, management plan, and personnel to be used are presented.

Minicars, Inc., 35 La Patera Lane, Goleta, Calif. 93017
Contract DOT-HS-6-01384
(n.d.); 26p
Availability: Reference copy only

HS-802 650

DEVELOPMENT OF A SOLID PROPELLANT INFLATION TECHNIQUE FOR THE SUBCOMPACT CAR PASSENGER RESTRAINT SYSTEM. PROGRESS REPORT FOR SEPTEMBER [1976]

A program plan has been written and submitted to the National Hwy. Traffic Safety Administration (NHTSA). New bids have been obtained from American Safety Equipment Co. for dynamic out-of-position child testing and from Thiokol for additional static out-of-position child testing. A program plan has been resubmitted with NHTSA's recommended modifications. Approval has been requested from NHTSA for awarding of a subcontract to Thiokol for inflator fabrication. Little work has taken place thus far of a hardware nature. Computer simulations have been deemphasized in lieu of increased testing. A

schedule is submitted, divided into two nine-month phases and including task descriptions and costs.

Minicars, Inc., 35 La Patera Lane, Goleta, Calif. 93017
Contract DOT-HS-6-01384
Rept. No. PR-Sep-76; (1976); 5p
Availability: Reference copy only

HS-802 651

DEVELOPMENT OF A SOLID PROPELLANT INFLATION TECHNIQUE FOR THE SUBCOMPACT CAR PASSENGER RESTRAINT SYSTEM. PROGRESS REPORT FOR OCTOBER 1976

National Hwy. Traffic Safety Administration (NHTSA) approval was obtained for the modified program plan. NHTSA approval was obtained to issue a $63,227 subcontract to Thiokol Corp. for inflator fabrication, reloading, and testing. A purchase order was issued to American Safety Equipment Co. for 20 dynamic out-of-position child tests. Static out-of-position child testing was scheduled with Thiokol Corp. A restraint system and simulated Simca compartment are being designed for out-of-position child tests at Thiokol. The latest version of Minicars research safety vehicle (RSV) right front passenger restraint system is being fabricated for testing. All hardware required for the first test series has been ordered, and most has been received. At the end of Oct the project was about three weeks behind schedule, due to delays in authorization from NHTSA. Diagrams of the passenger restraint system and the RSV inflation sequence are included. A schedule is submitted, divided into two nine-month phases and including task descriptions and costs.

Minicars, Inc., 35 La Patera Lane, Goleta, Calif. 93017
Contract DOT-HS-6-01384
Rept. No. PR-Oct-76; 1976; 8p
Availability: Reference copy only

HS-802 652

DEVELOPMENT OF A SOLID PROPELLANT INFLATION TECHNIQUE FOR THE SUBCOMPACT CAR PASSENGER RESTRAINT SYSTEM. PROGRESS REPORT FOR NOVEMBER 1976

Primary effort was concentrated in procuring hardware and preparing for static out-of-position child tests to be conducted at Thiokol Corp. during Dec. All hardware was completely fabricated or scheduled for completion by the Dec 6 test date. The sled compartment for sled testing was 90% completed, with only the dash area remaining to be finished. Dash area work is stopped pending results of the out-of-position child tests at Thiokol, which will establish pertinent dash/seat relationships and dimensions. A schedule is submitted, divided into two nine-month phases and including task descriptions and costs.

Minicars, Inc., 35 La Patera Lane, Goleta, Calif. 93017
Contract DOT-HS-6-01384
Rept. No. PR-Nov-76; 1976; 5p
Availability: Reference copy only

HS-802 653

DEVELOPMENT OF A SOLID PROPELLANT INFLATION TECHNIQUE FOR THE SUBCOMPACT CAR PASSENGER RESTRAINT SYSTEM. PROGRESS REPORT, DECEMBER 1976

Five static tests using the out-of-position child dummy were conducted as part of developmental work for a solid propellant inflation technique for a subcompact car passenger restraint system. The restraint system up to this point was primarily tested in a dynamic crash environment with adult dummy sizes, and these static child tests were conducted in an effort to further tune this basic restraint system to meet the requirements of the smaller anthropomorphic passenger sizes. Since previous static out-of-position child tests had indicated bagslap was not a problem, concentration in this series of tests was placed on those parameters that would deal more directly with the anticipated problem area, namely excessive head injury criteria (HIC) values during head contact with the seat back during the rebound phase. The following parameters, therefore, were selected to remain constant for these tests: seat position relative to the airbag launch point, dummy position relative to the seat back and inflator, airbag design, and dash construction. Parameters selected for variation were: airbag venting, airbag folding technique, inflator flow angle from horizontal, and amount of propellant in the inflator. In general, results show that when the restraint system is fired statically with the child leaning against the dash, very low injury measures are produced which shows a great deal of promise for the dynamic out-of-position tests. The good preliminary performance in this test mode is attributed to the combination of low inflator mount, bag folding, and the dual compartment air bag. All of these factors work together to produce a deployment configuration that varies with passenger size. For small passengers, the bag remains very low so that only the head bag contacts the passenger; for larger passenger sizes, the bag deploys normally with full bag contact on the head torso. Additional testing with the six-year-old child dummy in both the static and dynamic test modes in various out-of-position configurations are necessary to further verify these preliminary results. Photographs and graphical test data are included for all the tests.

Minicars, Inc., 35 La Patera Lane, Goleta, Calif. 93017
Contract DOT-HS-6-01384
1977; 44p
See also HS-802 652, HS-802 654--HS-802 660.
Availability: Reference copy only

HS-802 654

DEVELOPMENT OF SOLID PROPELLANT INFLATION TECHNIQUE FOR THE SUBCOMPACT CAR PASSENGER RESTRAINT SYSTEM. PROGRESS REPORT, JANUARY 1977

One static test using a normally seated, 50th percentile male dummy and seven static and ten dynamic tests using the out-of-position child dummy were conducted as part of developmental work for a solid propellant inflation technique for a subcompact car passenger restraint system. The static test using the adult dummy was conducted to verify that the bag folding-deployment technique that worked well for earlier static out-of-position child tests would also perform well for the adult. Results indicate that the system would deploy properly for the adult size range of passengers and still not

pose a threat to the out-of-position child. Next seven out-of-position static tests with the child dummy were conducted, some using a 420-gram propellant charge for the inflator and others a 460-gram charge. Also, the position of the child dummy relative to the inflator was varied. Position A consisted of placing the dummy in the seat in such a way that its back was almost vertical and its chest was located between 6 and 8 inches from the air bag. In Position B the dummy was seated with its chest between 5 and 6 inches from the air bag and with brow resting on the dash and mouth placed on the air bag. Position C was similar to Position B, the only difference being that the torso was inclined at a still greater angle toward the dash so that its entire face rested against the air bag and inflator. The C Position was found to result in the highest injury measures, but these measures are still relatively mild. It was decided after these static tests were completed that the system had been tuned to the point where it was ready to be checked out in a dynamic test environment. Ten dynamic out-of-position child tests were conducted. In all the sled runs in this series the inflator propellant load was 460 grams, the seat was adjusted to the mid-adjustment position, and the six-year-old child dummy was used. Injury criteria were not met in these sled tests; further testing with changes in inflator charge and changes in the air bag are required. Data for all out-of-position child tests are presented in tabular and graphical form.

Minicars, Inc., 35 La Patera Lane, Goleta, Calif. 93017
Contract DOT-HS-6-01384
1977; 92p
See also HS-802 652--HS-802 653, HS-802 655--HS-802 660.
Availability: Reference copy only

HS-802 655

DEVELOPMENT OF SOLID PROPELLANT INFLATION TECHNIQUE FOR THE SUBCOMPACT CAR PASSENGER RESTRAINT SYSTEM. PROGRESS REPORT, FEBRUARY 1977

Nine sled tests using adult dummies were conducted as part of developmental work for a solid propellant inflation technique for a subcompact car passenger restraint system. These tests were conducted in light of earlier tests that showed some modifications to the basic airbag design would be necessary to improve system performance for the out-of-position child. Several changes appear attractive such as reducing the inflator charge and bag volume or adding a vent to the torso bag. Prior to implementation of these changes, it was felt necessary to evaluate the effect of these changes on full size, normally seated passengers. Results of these tests using the 50th percentile dummy show that a new airbag design enabled the injury criteria at 45 mph to be met with an inflator that has a reduced propellant charge. This new inflator/airbag combination will result in lower injury levels for the out-of-position child. Data for all tests are presented in tabular and graphical form.

Minicars, Inc., 35 La Patera Lane, Goleta, Calif. 93017
Contract DOT-HS-6-01384
1977; 39p
See also HS-802 652--HS-802 654, HS-802 656--HS-802 660.
Availability: Reference copy only

HS-802 656

DEVELOPMENT OF SOLID PROPELLANT INFLATION TECHNIQUE FOR THE SUBCOMPACT CAR PASSENGER RESTRAINT SYSTEM. PROGRESS REPORT, MARCH 1977

Sled tests were conducted and preliminary integration of the Minicars right front passenger restraint system into the Calspan research safety vehicle (RSV) dash was performed as part of developmental work for a solid propellant inflation technique for a subcompact car passenger restraint system. Three sled tests were conducted using the 50th percentile dummy. In an effort to enable the air bag to absorb more of the passenger kinetic energy in "ridedown," the airbag inflator used in these tests was modified by reducing the thickness of 150 grams of the total 420-gram propellant charge from the standard 0.120 inch to 0.060 inch thickness. This reduction in thickness increases the surface area of the propellant exposed to the flame front, resulting in a faster, hotter burn. Since the propellant weight remains unchanged, the total energy is not much different; only the flow rate history is affected. Using this new formulation, the time at which maximum rate of gas flow from the inflator occurs is somewhat earlier than before. It was hoped that this would result in a faster airbag inflation rate with a concomitant increase in the amount of energy absorbed in "ridedown." Since the first test used the same airbag design and total propellant charge weight as was used in a previous test, a good basis of comparison was obtained. In this test, the modified inflator did pressurize the bag faster; however, peak chest g's were slightly higher than those of the earlier test. This increase is attributed to the size of the vent area which was slightly smaller for the "hotter" inflator. Another difference was the lower head injury criteria (HIC) measurement obtained in this test compared to the earlier one. To reduce peak chest g's, the vent area in the air bag was increased by 30% for the second test. This modification further improved performance. Peak chest g's were reduced to 50 g's (versus 57 g's in first test) and HIC was reduced to 528 (versus 655). The third test was the same as the second test except for three items. First, the air bag Design No. 5 (a deep bag designed for wraparound) was changed to a Design No. 4 air bag (a smaller volume bag that relies primarily on pressure to retard the passenger forward movement). Second, the inflator mount was raised 0.5 inch and trimmed 1.5 inches from the lower part of the dash. These modifications resulted in a total of two more inches of knee clearance between the dash and the knee. Third, the velocity was increased slightly to 49 mph (versus 45 mph). Results of this test show that even though the velocity was higher, the results were about the same as the second test. Data for all tests are presented in tabular and graphical form. With regard to integration of the restraint system into the Calspan RSV dash, figures are presented showing a perspective view of the restraint system installed in the dash and a section through the dash. At the present time, it is felt that this installation would require the following three modifications to the dash-knee bar: installation of an inflator mount, addition of a recessed area in the dash to allow additional knee restraint penetration, and extension of the air bag cover approximately 2 inches aft of the present aft face of the dash.

Minicars, Inc., 35 La Patera Lane, Goleta, Calif. 93017
Contract DOT-HS-6-01384
1977; 21p
See also HS-802 652--HS-802 655, HS-802 657--HS-802 660.
Availability: Reference copy only

HS-802 657

DEVELOPMENT OF SOLID PROPELLANT INFLATION TECHNIQUE FOR THE SUBCOMPACT CAR PASSENGER RESTRAINT SYSTEM. PROGRESS REPORT, APRIL 1977

Sled tests using adult and child dummies were conducted as part of developmental work for a solid propellant inflation technique for a subcompact car passenger restraint system. Four tests were conducted of the passenger restraint system at 45 mph for the 50th percentile male dummy. Results indicated that the Design No. 4 air bag (a smaller volume bag relying primarily on pressure to retard passenger forward movement) results in injury measures slightly lower than those in which the Design No. 5 air bag (a deep bag designed for wraparound) is used, and that very little difference exists between the performance of the two different 420-gram inflators, i.e. one inflator type had 420 grams of a single pellet size (0.120 inch thick) while the other had 420 grams of two different pellet sizes (0.120 and 0.060 inch thick). Since the system had been tuned to provide reliable and repetitive operation with low injury measures for the 50th percentile male, tests were conducted using the 95th percentile male. Results from three out of five such tests indicated there was not enough energy absorption in the system to provide protection at 45 mph barrier equivalent velocity (BEV). In all three cases the head injury criteria (HIC) was slightly above 1000. It was found, however, that the Design No. 4 air bag was slightly superior in performance to that of the Design No. 5 air bag. In an effort to absorb more of the passenger's energy in "ridedown" without changing the bag design or venting characteristics, it was decided to increase the knee restraint crush force. The knee restraint was modified by imbedding a layer of 26-gauge sheet steel four inches forward of the front face of styrofoam. This change enabled the knees to penetrate four inches of foam before engaging the sheet metal. As the knees penetrate further, the sheet metal would effectively increase the area of foam being crushed. A further change was designed to increase the stroking force of the foam and hence, the effective area of the knee contact. For this modification, the whole knee restraint would be encased in one-quarter inch thick ensolite. The improved knee restraint resulted in injury measures substantially below the allowable limits of 45 mph BEV for the 95th percentile male. This testing was followed by two tests of the normally seated, six-year size child dummy. In the first test, gas leaked from the end cap of the inflator and burned a large hole in a highly stressed portion of the air bag, the reason for which is not known at the present time. This situation triggered a rip which culminated in a larger hole approximately eight inches in diameter. Since the bag lost pressure early in the event, the child dummy bottomed out the bag and received high injury measures. In the second test with the child dummy, the setup was the same as that in the previous run which was, in turn, identical to the setup found to result in the lowest injury measures for the 50th and 95th percentile males. In this test the inflator functioned normally. However, since the child dummy slid forward off the seat and fell onto the unpadded steel floor, the chest S-I acceleration was excessive. It may be possible to attenuate the chest S-I acceleration either by installing carpeting or by changing the configuration of the knee restraint. Pre-test and post-test photographs and sled test data in graphical form are appended.

Minicars, Inc., 35 La Patera Lane, Goleta, Calif. 93017
Contract DOT-HS-6-01384
1977; 71p
See also HS-802 652--HS-802 656, HS-802 658, HS-802 660.
Availability: Reference copy only

HS-802 658

DEVELOPMENT OF SOLID PROPELLANT INFLATION TECHNIQUE FOR THE SUBCOMPACT CAR PASSENGER RESTRAINT SYSTEM. PROGRESS REPORT, MAY 1977

Sled testing using child dummies was conducted and an air cushion restraint system (ACRS) dashboard design integration study was initiated as part of developmental work for a solid propellant inflation technique for a subcompact car passenger restraint system. Ten tests were conducted, and in all tests the inflator propellant load was 420 grams, the seat was fixed in the mid-adjustment position, and the six-year size child dummy was used. Test results are tabulated and include peak chest accelerations, chest severity index (CSI), head injury criteria (HIC), and remarks. A brief description of test conditions and a summary of post-test observations on high-speed photography are given for each test. Also, photographs of dummy pre-test configuration, dummy post-test configuration, and time sequence of bag deployment and occupant arrestment are provided for the individual tests. One anomaly noted in the test series was premature loss of gas during bag deployment. This problem has been attributed to the "fit" of the bag over the inflator. It has been observed that a tight fitting diffuser sock appears to cause excessive membrane stretching of the sock during bag pumping, leading to its separation from the end fittings and subsequent loss of gas. A second anomaly noted for certain tests was the apparent slow rate at which the head bag deployed and became fully pressurized. In several tests the head bag did not deploy fully until the dummy began rebound. This can seriously affect the performance of the bag because under these conditions only a fraction of the total bag volume is active. Other point of interest is the effect of the pre-test, stowed configuration of the bag on the bag pressure-time history. It is believed that either the tightness of the bag roll or the position of the stowed bag on the diffuser (or both) causes partial or total blockage of the inner membrane vent when the bag interacts with the dummy during deployment. If so, the bag pressure would reach a higher steady-state level and maintain higher pressures for a longer period of time. In viewing high-speed photography of the tests, it was determined that several tests having characteristically higher bag pressures resulted in a much slower head bag deployment (another indication of partial or total blockage of the inner membrane vent during deployment). Another problem that was encountered was the loss of the knee restraint during several tests. If the knee restraint should move excessively during bag deployment, the bag tends to fall toward the floor leaving inadequate bag support for the dummy's upper torso and head. With respect to the ACRS/dashboard design integration study, figures are presented which show the design integration concept currently being pursued at Minicars, the geometry of the dashboard envelope as defined to date, and the geometry of the supporting bulkheads. This dashboard configuration will be used in the next series of dynamic out-of-position child tests. Appendices provide the measured results for the air bag, sled, and dummy.

Minicars, Inc., 35 La Patera Lane, Goleta, Calif. 93017
Contract DOT-HS-6-01384
1977; 87p
See also HS-802 652--HS-802 657, HS-802 660.
Availability: Reference copy only

HS-802 659

DEVELOPMENT OF A SOLID PROPELLANT INFLATION TECHNIQUE FOR THE SUBCOMPACT CAR PASSENGER RESTRAINT SYSTEM. PROGRESS REPORT, JUNE 1977

Sled tests using adult dummies conducted as part of developmental work for a solid propellant inflation technique for a subcompact car passenger restraint system included installing the Calspan research safety vehicle (RSV) dash unit in the Simca sled compartment. For sled testing, a "boilerplate version" of this dash unit was fabricated from 0.090-inch thick mild steel sheet. The only change made to the dash geometry was in the knee bolster which was recessed 1 inch deeper to allow for yielding that would occur in the actual vehicle dash constructed from 0.030-inch thick material. The inflator holder was integrated into the dash by locating the two bulkheads extending to the firewall and fastened to the dash top to accept the standard inflator mounting bracketry. Sled tests were then scheduled to check out the new dash as well as to determine whether the propellant charge was desired because results of the out-of-position 45-mph sled tests were marginal in terms of meeting the injury criteria. It was felt that reducing the propellant charge would enable the injury criteria for the out-of-position child to be satisfied. Therefore, before conducting the out-of-position child test series, it was felt necessary to demonstrate that reduced inflator loads would not compromise adult performance. Three sled tests were scheduled. Normally seated, 50th percentile dummies and inflators loaded to reduce bag slap and catapult effects on small, out-of-position passengers were used in these tests. The burn rate of the propellant was slowed down from earlier testing, and in two of the three tests the propellant charge was reduced from 420 grams (as used in earlier tests) to 400 grams. The Design No. 4 air bag used in the previous test series was modified to be two inches narrower in the torso width direction and designated as Design No. 6. From the results of these tests it appears that the inflators can probably be used satisfactorily to protect full-sized passengers. In two of the tests, there is no doubt of this fact since both dummies easily met the injury criteria and had adequate room left in the compartment so that the 95th percentile would not "bottom out." In the third test the conclusions are not as obvious, since the seat came loose from its tracks and impacted the dummy's chest and back. It appeared from the data traces, however, the chest g's had leveled off at approximately 50 g and had just begun to decrease before the seat back impacted the chest. Based upon this fact and the obvious fact that head injury criteria (HIC) would also decrease from the 722 value had this freak impact not occurred, it is felt that this inflator would also perform well with the adult passenger sizes. On the basis of these results, the two 400-gram inflators have been selected as candidates for the out-of-position child test series scheduled at the American Safety Equipment Company (ASE).

Minicars, Inc., 35 La Patera Lane, Goleta, Calif. 93017
Contract DOT-HS-6-01384
1977; 30p
See also HS-802 652--HS-802 658, HS-802 660.
Availability: Reference copy only

HS-802 660

DEVELOPMENT OF A SOLID PROPELLANT INFLATION TECHNIQUE FOR THE SUBCOMPACT CAR PASSENGER RESTRAINT SYSTEM. PROGRESS REPORT, AUGUST 1977

Developmental work for a solid propellant inflation technique for a subcompact car passenger restraint system is reported. A series of sled (with a new metering pin) tests of the out-of-position, six-year size child dummy as occupant has been proposed with the objective of obtaining a crash pulse more nearly like the actual Calspan research safety vehicle (RSV) pulse than that obtained in earlier testing which contributed to injury measures 10% to 20% in excess of the allowable values. It is also planned to ascertain during these tests the velocity to which the restraint system could be operated and still "pass" the injury criteria. A curve showing a comparison between the Calspan RSV pulse and sled pulse used in the last test series is presented. A curve comparing the Calspan RSV pulse with an unmodified Volvo, and the Minicars RSV pulse is also presented. The Calspan RSV pulse has generally higher g's and a much more rapid onset rate than do the other two. This very quick pulse rise time translates itself into high relative velocity between the child and the compartment that builds up quickly. This means that the child very often travels the short distance between his/her chest and the air bag (approximately 4 inches) before the bag is fully deployed, resulting in the dummy impacting its chest and head on the dash and the inflator. The injury measures received for the out-of-position child may thus be more severe than they would be for most other vehicles where the pulse onset rates and crash pulse g-levels are generally less severe. Efforts have been made to negotiatiate a new test series with ASE. Testing will begin on 26 Sep and be completed on 30 Sep.

Minicars, Inc., 35 La Patera Lane, Goleta, Calif. 93017
Contract DOT-HS-6-01384
1977; 6p
See also HS-802 652--HS-802 659.
Availability: Reference copy only

HS-802 661

DEVELOPMENT OF THE ASPIRATION INFLATION TECHNIQUE FOR SUBCOMPACT CARS - FRONT-SEAT PASSENGER. PROGRESS REPORT NO. 1, 1 JULY 1975 TO 10 AUGUST 1975

In developmental work for an aspiration inflation system for protection of front-seat passengers in subcompact cars, a project plan was formulated and submitted by the contractor, Calspan Corp., to the Dept. of Transportation (DOT); an initial briefing at DOT was held on 5 Aug 1975; and technical and planning discussions were held between Calspan and the Thiokol Corp., including agreement on a subcontract work statement.

by David J. Romeo
Calspan Corp., P.O. Box 235, Buffalo, N.Y. 14221
Contract DOT-HS-5-01254
1976?; 3p
See also HS-802 662--HS-802 685.
Availability: Reference copy only

HS-802 662

DEVELOPMENT OF THE ASPIRATION INFLATION TECHNIQUE FOR SUBCOMPACT CARS - FRONT-

SEAT PASSENGER. PROGRESS REPORT NO. 2, 11 AUGUST 1975 TO 31 AUGUST 1975

In developmental work for an aspiration inflation system for protection of front seat passengers in subcompact cars, a resubmitted subcontract proposal from the Thiokol Corp. has been received, effort on a computer simulation study was initiated, and the car selection for the program is still in progress. For the computer simulation study, the following inputs are required for the adult, normally seated occupant: dummy characteristics, dummy initial posture, seat properties, force deflection properties for the target areas, vehicle interior dimensions, and vehicle crash deceleration profile. Initial force deflection properties for the knee bar and air bag will be based upon data which were obtained during an air bag bolster program (presented herein as well as the faired curves which will be used in the simulations). The Volvo 244 or the AMC Pacer will most likely be the test vehicle for this program. In the meantime both interior geometries are being studied. Surprisingly, the initial occupant posture, that is the foot-knee-hip-shoulder position, is similar for the two cars. Additionally, the dummy-head-to-vehicle-header distance is also the same in both cars. Since the target properties for the knee bar and air bag are not dependent on car choice at this time, it appears that the only major distinctions between the two cars will be dash panel location and car deceleration profile. With regard to dash location, the pre-crash location of the Volvo dash is some 6 to 8 inches closer to the occupant than the Pacer and post-test it appears that this difference will be close to 12 inches. The post-crash (here it is assumed that the study will be based upon a 45 mph frontal crash condition) interior geometry is a primary determinant of the vehicle selection. Furthermore, the post-test interior geometry will greatly influence the protection afforded by the restraint system. Accordingly provision will be made in the computer simulations and in the sled test series to recognize the post-test interior geometry of the vehicle.

Calspan Corp., P.O. Box 235, Buffalo, N.Y. 14221
Contract DOT-HS-5-01254
1976?; 7p
See also HS-802 661, HS-802 663--HS-802 685.
Availability: Reference copy only

HS-802 663

DEVELOPMENT OF THE ASPIRATION INFLATION TECHNIQUE FOR SUBCOMPACT CARS--FRONT-SEAT PASSENGER. PROGRESS REPORT NO. 3, 1 SEPTEMBER 1975 TO 5 OCTOBER 1975

A plan for executing computer simulations of the crash environment was developed and a test vehicle was selected in developmental work for an aspiration inflation system for protection of front-seat passengers in subcompact cars. The plan calls for simulating various restraint (air bag and knee bar with variations in geometry and bag inflation characteristics) and occupant conditions (50th percentile male, 95th percentile male, 5th percentile female in various seating positions) within the 1975 Volvo 244 interior. A complete variation of all parameters within the matrix is not planned. Rather, a selection of runs duplicating sled test conditions will be performed first in support of the planned experimental effort. Other "worst case" parameter sets will be selected, particularly those representing configurations that cannot be examined experimentally. The CVS-III (crash victim simulation) three dimensional computer program will be used; parameter input is being prepared accordingly. At the present time, data are availabl describing the interior geometry of the Volvo and its cras deceleration characteristic. Initial runs will employ air bag an knee bar force-deflection characteristics. It is estimated tha ten to twenty simulation runs will be performed, some which will be with the functioning airbag subroutine. Calspa has purchased a Volvo 244 to facilitate layout of the restrai system. A mock-up of the system will be installed in the veh cle in order to ensure that there is available space and to wo out mounting details. The Volvo 244 has been crash tested Calspan at 46 mph and the resulting interior compartme deformation suggests that this test speed presents a reasonab goal for occupant protection using the aspirator airbag syste to be developed under this program. Vehicle deceleration da taken on the Volvo test have been used to obtain a mean cra deceleration profile (presented herein) which will be used the computer simulations. A peak deceleration pulse of 38 40 g's (which would be obtained at a filtering frequen between 15 HZ and 60 HZ) will be assumed for the purpos of this study.

Calspan Corp., P.O. Box 235, Buffalo, N.Y. 14221
Contract DOT-HS-5-01254
1976?; 7p
See also HS-802 661--HS-802 662, HS-802 664--HS-802 685.
Availability: Reference copy only

HS-802 664

DEVELOPMENT OF THE ASPIRATION INFLATION TECHNIQUE FOR SUBCOMPACT CARS - FRONT-SEAT PASSENGER. PROGRESS REPORT NO. 4, 6 OCTOBER 1975 TO 2 NOVEMBER 1975

In developmental work for an aspiration inflation system protection of front-seat passengers in subcompact cars, co puter simulations were initiated, a restraint system layout i Volvo was obtained, a subcontract to the Thiokol Corp. v awarded, and a hardware design for a workhorse system v completed. The input data set for the CVS-III (crash vict simulation) three-dimensional Volvo simulation was complet An initiation run was executed to verify the suitability of input parameters. Subsequent to this, a full-length run v conducted in which a contact ellipsoid bag restraint algorit was used. The simulation results, though modest in terms injury criteria, did indicate a need to make adjustments in seated position of the occupant. The BAGSLAP simulat was accessed on Calspan's terminal in order to execute a sa ple run and to obtain an up-to-date program listing. Th modynamic data for the simulation were obtained fr Thiokol and other required data have been postulated on basis of existing design information. Three subsets of vehi environment parameter input will be used to execute r simulating the out-of-position child occupant. In addition, t gas flow and two torso offset configurations will be combi with the three vehicle acceleration conditions to provid matrix of 12 simulation runs. A progress report (No. 1, 1975) of system support work (airbag computer simulatio aspirating inflator design, computer analysis and simulation ejector performance) conducted by Thiokol under subcontr to Calspan is appended and forms the major part of presentation.

Calspan Corp., P.O. Box 235, Buffalo, N.Y. 14221
Contract DOT-HS-5-01254
1976?; 33p
See also HS-802 661--HS-802 663, HS-802 665--HS-802 685.
Availability: Reference copy only

HS-802 665

DEVELOPMENT OF THE ASPIRATION INFLATION TECHNIQUE FOR SUBCOMPACT CARS--FRONT-SEAT PASSENGER. PROGRESS REPORT NO. 5, 3 NOVEMBER 1975 TO 30 NOVEMBER 1975

In developmental work for an aspiration inflation system for protection of front-seat passengers in subcompact cars, bagslap and three dimensional occupant model computer simulations were conducted, fabrication of workhorse hardware was initiated, and fabrication of an aspirator mock-up was initiated. Three restraint system configurations employing a 50th percentile male occupant (in a Volvo at impact speed of 48 mph) were run using the CVS-III (crash victim simulation) three-dimensional simulation with the AIRBAG subroutine. Two configurations were high and low flow inflation cases corresponding to aspirating and nonaspirating vented airbag conditions and the third was a nonvented low flow case. The CVS-III was also run for the out-of-position, 50 lb child. Two such runs were made which simulated the forward seated child in the presence of the inflating bag under high and low flow vented bag conditions; a static vehicle environment was employed. A summary of peak responses and corresponding injury criteria for all CVS-III simulations is presented in tabular form. Twelve simulations using the BAGSLAP computer program were performed for the out-of-position child occupant for various bag inflation, torso offset, and vehicle environmental conditions. A summary of the computed peak torso velocity with respect to the vehicle reference for each of the 12 runs is presented in tabular form. A progress report (No. 2, 1 Nov to 30 Nov 1975) of work for this effort conducted by the Thiokol Corp. under subcontract to Calspan Corp. is appended.

Calspan Corp., P.O. Box 235, Buffalo, N.Y. 14221
Contract DOT-HS-5-01254
1976?; 14p
See also HS-802 661--HS-802 664, HS-802 666--HS-802 685.
Availability: Reference copy only

HS-802 666

DEVELOPMENT OF THE ASPIRATION INFLATION TECHNIQUE FOR SUBCOMPACT CARS - FRONT-SEAT PASSENGER. PROGRESS REPORT NO. 6, 1 DECEMBER 1975 TO 11 JANUARY 1976

In developmental work for an aspiration inflation system for protection of front-seat passengers in subcompact cars, a mock-up of the system was completed, a sled buck layout was initiated, pre-test computer simulations and analysis of data were completed, fabrication of hardware for static tests was completed, and an instrumented six-year-size dummy and Volvo 244 bucket seat were shipped. The main portion of this report is an appendix describing the occupant crash simulations which were conducted by the Thiokol Corp. under contract to Calspan Corp. Two objectives were considered in organizing and executing the simulation effort. The first was an investigation of the normally positioned 50th percentile male occupant response to impact at 48 mph using one vehicle environment and several candidate airbag restraint system configurations. The second was an investigation of the hazard potential of the candidate restraint system to the out-of-position, 50 lb child occupant (static airbag deployment study). To accomplish these objectives, simulations of the normally seated occupant and the out-of-position child were performed using the three-dimensional crash victim simulation computer program (CVS-III) developed by Calspan; other simulations of the out-of-position child were performed using the BAGSLAP computer program developed by AMF. High flow and low flow mass flow rates were considered. The two flow conditions simulated were estimates of maximum and minimum gas generator-aspirator mass flow production. The effect of bag venting was also explored. For the 48 mph simulations, the low flow, 10 sq in vent case, produced the best injury criteria results, despite the occurrence of head-windshield contact. Low flow, 5 sq in venting was not quite as good, being perhaps a little too stiff. Occupant kinematics appeared well behaved. All results for the forward position child appear acceptable at both the low and high flow conditions. However, no occupant seat contact was allowed during rebound and the acceleration results are those occurring during travel out of the air bag. Overall simulation results appear encouraging with regard to incorporation of the proposed restraint system under actual experimental sled test conditions. The results indicate that the proposed system will be capable of providing protection to adults at a nominal 45 mph frontal barrier Volvo 244 crash profile without being injurious to the forward position child. Minimum margin of satisfaction of proposed dummy acceleration results occurs with respect to adult chest resultant acceleration. Also appended is a progress report (No. 3, 1 Dec to 31 Dec 1975) by Thiokol under subcontract to Calspan.

Calspan Corp., P.O. Box 235, Buffalo, N.Y. 14221
Contract DOT-HS-5-01254
1976?; 81p 12refs
See also HS-802 661--HS-802 665, HS-802 667--HS-802 685.
Availability: Reference copy only

HS-802 667

DEVELOPMENT OF THE ASPIRATION INFLATION TECHNIQUE FOR SUBCOMPACT CARS - FRONT-SEAT PASSENGER. PROGRESS REPORT NO. 7, 12 JANUARY 1976 TO 8 FEBRUARY 1976

In developmental work for an aspiration inflation system for protection of front seat passengers in subcompact cars, pre-sled testing was completed, a sled-test buck was fabricated, and a mock-up of the system was installed in a Volvo automobile. Results of the pre-sled testing (a series of eight static bag deployment tests and a series of six out-of-position child tests which were conducted by the Thiokol Corp. under subcontract to the Calspan Corp. are discussed in detail in a progress report (No. 4, 1 Jan to 31 Jan 1976) which is appended and forms the major part of this presentation. The results of these tests are considered successful and encouraging. First, the test results demonstrated conclusively that the system was aspirating, bringing the unvented bag to approximately 2.5 psig in the full aspiration case and to less than zero psig in the nonaspiration case. Second, in the full aspiration case the system with a selected bag folding technique did not appear hazardous to the forward position child. Photographs of the mock-up of the aspirator airbag system as installed in the Volvo 244 are presented; photographs of the sled buck will be presented in the next month's progress report.

Calspan Corp., P.O. Box 235, Buffalo, N.Y. 14221
Contract DOT-HS-5-01254
1976?; 36p
See also HS-802 661--HS-802 666, HS-802 668--HS-802 685.
Availability: Reference copy only

HS-802 668

DEVELOPMENT OF THE ASPIRATION INFLATION TECHNIQUE FOR SUBCOMPACT CARS - FRONT-SEAT PASSENGER. PROGRESS REPORT NO. 8, 9 FEBRUARY 1976 TO 7 MARCH 1976

Two series of developmental sled tests (total of nine) were conducted of an aspiration inflation system for protection of front-seat passengers in subcompact cars. Although the final configuration has not yet been determined, significant progress toward definition of an aspiration system capable of high speed, small car occupant protection has been made. In summary, the aspirator air bag system functions well under the high g-dummy impact environment to which it has been subjected; and at the end of Series 2 the dummy force, acceleration, and kinematic results are reasonably well under control with only the chest resultant acceleration results left to be resolved. Changes to lower the chest resultant acceleration to be considered in Series 3 include the following: increase bag size and gas volume, move knee bar forward 4 inches, move dash panel forward 4 inches, and increase bag fill time. A progress report (No. 5, 1 Feb to 29 Feb 1976) of work for this effort conducted by the Thiokol Corp. under subcontract to Calspan Corp. is appended.

Calspan Corp., P.O. Box 235, Buffalo, N.Y. 14221
Contract DOT-HS-5-01254
1976?; 23p
See also HS-802 661--HS-802 667, HS-802 669--HS-802 685.
Availability: Reference copy only

HS-802 669

DEVELOPMENT OF THE ASPIRATION INFLATION TECHNIQUE FOR SUBCOMPACT CARS - FRONT-SEAT PASSENGER. PROGRESS REPORT NO. 9, 8 MARCH 1976 TO 26 MARCH 1976

Funds expended are consistent with the progress made thus far; however, additional development of a gas generator will be undertaken which will account for an unanticipated expenditure of about $9000. Three changes to the system were proposed in order to upgrade the system to the point where the dummy data would satisfy presently accepted injury criteria. Two of these changes were made to the aspiration air-bag system which now at the end of Series-3 produces excellent dummy force, acceleration, and kinematic results. Three sled tests were conducted, all at the baseline crash test condition, 50th percentile male, normal seated position, 46 mph. Dummy kinematics continued to be excellent as obtained in Series-2. Injury criteria data improved, with decreasing head and chest resultant accelerations. Data traces, test figures, and photographs are included. An appendix presents Thiokol's sixth progress report.

Calspan Corp., P.O. Box 235, Buffalo, N.Y. 14221
Contract DOT-HS-5-01254
Rept. No. PR-9; 1976; 23p
Availability: Reference copy only

HS-802 670

DEVELOPMENT OF THE ASPIRATION INFLATION TECHNIQUE FOR SUBCOMPACT CARS - FRONT-SEAT PASSENGER. PROGRESS REPORT NO. 10, 29 MARCH 1976 TO 2 MAY 1976

Five static deployment tests were run at Thiokol; one static test and two out-of-position tests were run at Calspan; and the remaining 12 developmental sled tests were completed. Funds and progress are consistent with the program schedule. Further improvements upon the system were made by increasing the gas flow into the bag during inflation (propellent uploading) and increasing gas flow out of the bag during occupant loading (venting). Chest resultant injury criteria on the 50th percentile dummy at 46 mph with standard dash were thus satisfied, and chest results over Series 3 data with a four-inch dash extension were improved. Injury criteria were satisfied at 46 mph for not only the 5th and 95th percentile sizes but also for the six-year-old child size in both normal and forward seating positions. Data traces, test figures, and photographs are included. An appendix presents Thiokol's seventh progress report.

Calspan Corp., P.O. Box 235, Buffalo, N.Y. 14221
Contract DOT-HS-5-01254
Rept. No. PR-10; 1976; 49p
Availability: Reference copy only

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University of Manchester Inst. of Science and Technology, United Kingdom
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HS-021 460

University of Michigan
MEASUREMENT OF SHEAR FORCES DEVELOPED BETWEEN TIRE AND PAVEMENT
HS-021 370

TIRE-VEHICLE SYSTEM ELEMENTS BEARING ON THE PROBABILITIES OF LOSS OF CONTROL
HS-021 365

University of Michigan, Hwy. Safety Res. Inst., Huron Pkwy. and Baxter Rd., Ann Arbor, Mich. 48105
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DOT-HS-6-01386

Dunlap and Associates, Inc., 1 Parkland Drive, Darien, Conn. 06820
HS-802 608

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Minicars, Inc., 35 La Patera Lane, Goleta, Calif. 93017
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University of North Carolina, Hwy. Safety Res. Center, Chapel Hill, N.C. 27514
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University of Michigan, Hwy. Safety Res. Inst., Huron Pkwy. and Baxter Rd., Ann Arbor, Mich. 48105
HS-802 622

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State of Washington Dept. of Motor Vehicles, Highways-Licenses Bldg., Olympia, Wash. 98504
HS-802 618

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State of Washington Dept. of Motor Vehicles, Highways-Licenses Bldg., Olympia, Wash. 98504
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HPR-1(15)

Purdue Univ., Joint Hwy. Res. Proj., Civil Engineering Bldg., West Lafayette, Ind. 47907
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NGR-47-005-81

Department of Transportation, Transportation Systems Center, Kendall Square, Cambridge, Mass. 02142
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CONTRACTS AWARDED

DOT-HS-7-01642

NDR RAPID RESPONSE SYSTEM SUPPORT SERVICES

Technical support and assistance shall be provided to the National Highway Traffic Safety Administration (NHTSA) in order that it might proceed with the development of required justifications related to the potential National Driver Register (NDR) rapid response system. All tasks will lead to the formal documentation required to seek system approval. The specific areas to be addressed are as follows: development of a communications alternatives component for the implementation plan in a form suitable to meet all Federal requirements; feasibility of and rationale supporting the need for a NDR rapid response telecommunications system; cost-benefit analysis for use in justifying conversion from a batch/mail to an on-line rapid response system; development of a privacy and security plan encompassing the internal operations of the NDR, the State requirements and the communications requirements for each alternative that will satisfy the stipulations of the Privacy Act of 1974; preparation of draft cooperative agreements or contracts for NDR use when negotiating agreements with states (should also address the Privacy Act of 1974 requirements); estimation of the impact of the proposed legislative change related to operational considerations, personnel resources needed, overall cost and the communications alternatives; and definition of the hardware capability required in sufficient detail to enable the agency to convey this need in a comprehensible form to its supplier(s). Phase I will concern system analysis and design activities; Phase II will involve developing state interface requirements and implementation plan. 0lor

Richard L. Deal and Associates, Inc., 10560 Main Street, Fairfax, Virginia 22030
$69,627.29
To be completed one hundred and fifty-five (155) days from date of contract award (5/26/77).

DOT-HS-7-01643

DEVELOPMENT AND APPLICATION OF ANALYTICAL AND STATISTICAL METHODS IN VEHICLE STRUCTURES RESEARCH II

Engineering, mathematical-analysis, and computer-oriented services shall be provided in support of Highway Traffic Safety Research in the study of vehicle structures. The development and application of analytical and statistical methods in structures research requires extensive software generation, data collection, and data handling. Specific tasks shall be performed in the following areas: vehicle and occupant simulation programs, optimization models and programs (Ford Safety Optimization Model), installation of SARP (Storage and Retrieval Processor: data base management system) on the PDP 11/40, static crush data for vehicle front and side structures, dynamic crash data for vehicle front and side structures, and data coding and collation (MDAI (Multi-Disciplinary Accident Investigation) and FHWA (Federal Highway Administration) data files). 0n n

"This contract is awarded by the Small Business Administration under the authority of Section 8(a) of the Small Business Act (USC 637a), and will be administered by the Department of Transportation, National Highway Traffic Safety Administration."
$190,949.00
To be completed one (1) year from date of contract award (6/8/77).

DOT-HS-7-01645

MOTOR VEHICLE BRAKE FLUIDS

Motor vehicle brake fluid samples shall be tested in accordance with FMVSS No. 116 (National Highway Traffic Safety Administration's (NHTSA) Office of Standards Enforcement (OSE) Laboratory Test Procedure TP-116-02 dated November 1973). ing

Southwest Research Institute, 8500 Culebra Road, San Antonio, TX 78284
Per Delivery Order
To be completed twelve (12) months from date of contract award (6/26/77).

DOT-HS-7-01646

MOTOR VEHICLE BRAKE FLUIDS

Motor vehicle brake fluid samples shall be tested in accordance with FMVSS No. 116 (National Highway Traffic Safety Administration's (NHTSA) Office of Standards Enforcement (OSE) Laboratory Test Procedure TP-116-02 dated November 1973). 0).

Foster D. Snell, Inc., 66 Hanover Road, Florham Park, NJ 07932
Per Delivery Order
To be completed twelve (12) months from date of contract award (6/26/77).

DOT-HS-7-01647 IA

KINEMATIC AND KINETIC CHARACTERIZATION OF THE HUMAN NECK - II

Experimental studies and data analysis shall be conducted in an effort to better understand the kinematic and kinetic characteristics and prevalent injury modes of the human head-neck complex in a crash environment. The objectives of this research are as follows: to conduct sufficient tests using human volunteers and suitable lower order primates to define the kinematics of the head-neck complex in six acceleration directions; plus or minus Gy, plus or minus Gx, plus or minus Gxy (plus or minus 45°), and postulate and verify mechanical analogs of minimum articulation which impose the same kinematic and kinetic constraints between the head and T-1 as does the actual anatomical structure.

Naval Aerospace Medical Research Laboratory
$250,000.00
To be completed twelve (12) months from date of contract award (6/28/77).

DOT-HS-7-01650

OPTIMUM FREQUENCY OF INSPECTION

The optimum frequency of inspection of brake systems for vehicles under 10,000 pounds as part of a motor vehicle inspection (MVI) program shall be determined. The objectives of this contract are as follows: to perform a review and synthesis of past vehicle-in-use brake research; to perform a review of current State experimental wheel removal brake inspection programs; to conduct a search of current data from industry sources (OEM (original equipment manufacturer), replacement and repair); to develop an optimum brake inspection program in terms of brake performance and/or component condition, effectiveness and frequency of the inspection, and equipment; and to tabulate State data into a computer program in such manner that projections of optimum brake inspection frequencies can be forecast when similar geographical and demographical conditions exist0 da

Ultrasystems, Inc., 2400 Michelson Drive, Irvine, California 92714
$48,518.00
To be completed twelve (12) months from date of contract award (6/15/77).

DOT-HS-7-01651 IA

PHARMACOKINETIC EFFECTS OF DRUGS ON DRIVING PERFORMANCE

Research on the pharmacokinetic effects of certain drugs on specific driver skills in a driving simulator shall be conducted. This research will be added on to an on-going National Institute on Drug Abuse (NIDA) contract (271-76-3316) which is involved in the testing of the effects of seven (7) drugs on the performance of a variety of laboratory tasks designed to measure basic behavioral mechanisms. (Each of these drugs is being investigated by analyzing the time history of their concentrations in body fluids (no behavioral testing), by pilot studies to determine those behavioral tests most sensitive to their effects, and by behavioral tests to determine the time course of performance changes.) For this contract, the same drugs (if warranted) shall be tested in a more realistic driving situation, in which the various individual behavioral processes are integrated into typical driving tasks. A suitable driving simulator shall be developed to represent the driving task. Evaluation of the simulator results and comparison of these results with the laboratory results will provide information regarding the nature of the effects of potentially hazardous drugs on driving performance. This information is vital to a full understanding of the drug/highway safety problem, and to subsequent countermeasure development activities. 0ard

National Institute on Drug Abuse, 11400 Rockville Pike, Rockville, Md. 20852
$488,000.00
To be completed two (2) years and ten (10) months from date of contract award (8/12/77).

DOT-HS-7-01652

ESTABLISHMENT OF ZONE CENTERS FOR NASS

Technical assistance and quality control shall be provided to the ten primary sampling unit (PSU) teams of the National Highway Traffic Safety Administration's (NHTSA) National Accident Sampling System (NASS) pilot test. The following are the general requirements for this contract: provide day-to-day assistance and oversight of PSU teams (assist through the use of site visits and other means of communications, the new NASS teams in establishing their facilities, procedures, and relationships with community agencies; and insure that field data collection efforts are efficient and consistent with the overall experimental design and sampling strategy of NASS), provide quality control over PSU data collection (insure that field personnel adhere to a correct and consistent interpretation of field data elements, and insure that the field data are accurately and completely coded using a common set of guidelines for definition and format), and provide extra trained team members to each PSU during designated times of data collection. 0nd

Indiana University Foundation, 355 North Lansing Street, Indianapolis, Indiana 46202
$74,208.00
To be completed twenty-four (24) months from date of contract award (6/22/77).

DOT-HS-7-01655

PUBLIC EDUCATION AND INFORMATION - EMERGENCY MEDICAL SERVICE (EMS) FILM

In order to generate public awareness of emergency medical service (EMS) standard principles, techniques and programs and an understanding of the relationship between EMS activities and the National Highway Traffic Safety Administration (NHTSA), a film tentatively entitled "Emergency Medical Service" shall be produced. The film will be a 16mm color, optical sound motion picture of 28 1/2 minutes running time. It is to be of the nature and quality to make it suitable for television broadcasting, although its principal intended audience will comprise public officials and public-oriented citizens who can use the film as an initial guide for judging the adequacy of their own local emergency medical service. To serve this purpose the film must be informative, technically accurate, entertaining, dramatic, and visually and audibly exciting. The film must portray the role of the NHTSA in the EMS program, the nature and extent of the EMS program, proper emergency medical service operation, and the levels of emergency medical service appropriate to various sizes and types of communities.

Amram Nowak Associates, Inc., 1776 Broadway, New York City, New York 10019
$55,999.00
To be completed six (6) months from date of contract award (7/13/77).

DOT-HS-7-01657

IMPACT RESISTANCE OF NON-FERROUS PASSENGER CAR WHEELS

The impact resistance of non-ferrous passenger car wheels shall be investigated. The different ductility and fatigue properties of these light-weight alloy, non-ferrous wheels have introduced new failures on the highways in the form of fracturing and shattering on impact. There is need to explore new and/or modified evaluation methods for these wheels to assure

adequate safety performance. For this contract, a series of impact tests shall be performed on non-ferrous road wheels using the methodology of the proposed ISO (International Standards Organization) standard for wheel impact, a methodology regarded favorably by most wheel authorities. For comparison purposes, tests shall also be performed on pressed steel disc wheels designed for similar application and of similar load rating as the non-ferrous wheels. vis

Automotive Research Associates, Inc., 5405 Bandera Road, San Antonio, Texas 78238
$16,985.00
To be completed five (5) months from date of contract award (7/15/77).

DOT-HS-6-01658

EXTENSION OF TRAFFIC SAFETY PROGRAM MANAGEMENT MASTERS DEGREE PROGRAM

The Traffic Safety Program Management Fellowship/Internship graduate program developed by the University of Southern California (USC) shall be adopted by Indiana University as part of its master's degree in Public Administration. A minimum of 12 semester hours of graduate instruction will be provided within the traffic safety program management option. The first phase of the contract involves adopting the program; the second phase involves initiating the program, including recruitment of students and the offering of 12 fellowships/internships; the third phase involves evaluating the program and producing a final report. The objective of the fellowship/internship master's degree program is to provide management training for state and local traffic safety program managers. The program will provide professional education for personnel performing management functions in state traffic safety programs. As a result of the improved functioning of management personnel, it is expected that the state and local traffic safety program will become more efficient and effective in reducing deaths and injuries on the nation's highways, which is the ultimate goal of the National Highway Traffic Safety Administration (NHTSA)0rst

Indiana University, 355 North Lansing Street-Marion County, Indianapolis, Indiana 46202
$46,210.00
To be completed thirty-one (31) months from date of contract award (6/30/77).0

DOT-HS-7-01659

OCCUPANT SIDE IMPACT SIMULATIONS USING CVS PROGRAM

The National Highway Traffic Safety Administration's (NHTSA) Crash Victim Simulator (CVS) Computer Program shall be developed from its present general format to a more specific and concise model to simulate occupant side impacts. This simulation model will be used to study the gross motion and dynamic response of a vehicle occupant during side impact. In addition, it will be a useful tool for conducting parametric and optimization studies for the development of side impact protection. For a given crash environment, the model shall be able to simulate the major responses of cadaver, dummy and living occupants so that comparison can be made and relationship established between the occupant responses. It is, thus, expected that three mechanical idealizations, one each for the dummy, cadaver and living occupant, be developed and validated. The validation of the model is to be established by comparing computer model responses with test results. A simple quantitative procedure shall be developed to measure the relative degree of agreement of similarity between simulated model responses and experimental test results. This will render the comparison more objective and facilitate the development and validation of the model. The end product of this effort will be a user-oriented side impact simulation system complete with data base which will provide the input parameters needed to describe crash victims and to characterize the contact force relationship of the impacting materials. By refining the CVS program, the extensive and costly testing procedure currently employed in obtaining the necessary input data will be circumvented, and thus, make the simulation model more cost effective

The Regents of the University of Michigan, 260 Research Administration Building, The University of Michigan, Ann Arbor, Michigan 48105
$267,770.00
To be completed eighteen (18) months from date of contract award (9/28/77).

DOT-HS-7-01660

DATA FOR VALIDATION OF CRASH VICTIM SIMULATOR

A series of replicate sled tests shall be conducted to obtain data for the Crash Victim Simulator (CVS) model validation effort being performed by Calspan Corporation under Contract DOT-HS-6-01300 with the National Highway Traffic Safety Administration (NHTSA). A minimum of three (3) replicate sled tests for each of the following two (2) test configurations shall be conducted: frontal sled deceleration with a Type-2 belt restraint system with energy-absorbing belt force limiters installed at the three anchorage points; and frontal sled deceleration with a pre-inflated, production-type passenger air bag system. Each sled test will simulate a 30 mph vehicle impact using a 50th-percentile male anthropomorphic dummy. 0ade

Calspan Corporation, 4455 Genesee Street, Buffalo, New York 14221
$248,014.00
To be completed one (1) year from date of contract award (9/30/77).

DOT-HS-7-01661

ANATOMICAL CROSS-SECTIONAL GEOMETRY AND MASS DISTRIBUTION FOR CHILDREN

The cross-sectional geometry for children for geometrical input to finite element and lumped parameter biodynamic models shall be determined. Using either frozen sections or X-ray scans, photographic and/or graphical descriptions shall be developed, for the entire body, of cross sections spaced apart by approximately one two-hundredth (1/200th) of the head-to-toe body length for each of at least five (5) child cadaver specimens with body lengths of approximately 1-1/2, 3, 3-1/2, 4 and 4-1/2 feet respectively. Key anatomical components shall be digitized. Inertia tensors and masses for body segments shall be estimated and corresponding inputs to the three-dimensional Crash Victim Simulator (CVS) developed by the

Calspan Corporation shall be developed. Geometric correction rules (i.e., geometric transformation rules) shall be sought that modify a base internal and external geometry (e.g., the geometry of one of the specimens) so it applies, approximately, to other specimens and can be used for interpolation. ve

Georgetown University, 37th and O Streets, N.W., Washington, D.C. 20057
$152,085.00
To be completed one (1) year from date of contract award (9/23/77).

DOT-HS-7-01664

IDENTIFICATION OF SUPERIOR ENERGY-ABSORBING MATERIALS FOR SCHOOL BUS INTERIORS

Superior energy-absorbing materials for school bus interiors shall be identified. Detailed criteria necessary to evaluate the short- and long-term applicability of different energy-absorbing materials for use in occupant protection in school bus collisions shall first be obtained. The following considerations will be involved: energy absorption; flammability; toxicity and smoke obscuration; producibility and aesthetic acceptability; cost weight, and recyclability; and maintainability, environmental, and vandal resistiveness. Next, the properties of a number of padding material candidates will be defined by evaluation to the developed criteria covering the preceding considerations, via a literature search supplemented by testing where data are needed. Finally, the superior energy-absorbing materials (existing, improved, or contractor-developed materials) meeting stringent criteria for all the preceding considerations for school bus interiors will be identified. These materials will be evaluated for energy absorption criteria based on head, side, face, and femur protection of occupants ranging from the 50th-percentile adult male to the 6-year-old child. 0ill

ASL Engineering, Inc., 495 S. Fairview Avenue, Goleta, California 93017
$143,417.00
To be completed twelve (12) months from date of contract award (8/3/77).

DOT-HS-7-01665

OPERATION, MAINTENANCE AND UPDATE OF THE OSE (OFFICE OF STANDARDS ENFORCEMENT) AUTOMATED REPORTING SYSTEM

The operation, maintenance, and update of the National Highway Traffic Safety Administration's (NHTSA) Office of Standards Enforcement (OSE) Automated Reporting System shall be conducted. The Automated Reporting System consists of the OSE Periodic Reports System and the Tire Test Data Management System.

Kappa Systems, Inc., 1501 Wilson Boulevard, Arlington, Virginia 22209
$99,863.00
To be completed one (1) year from date of contract award (7/15/77).

DOT-HS-7-01666

SPECIAL MOTOR VEHICLE DIAGNOSTIC INSPECTION DEMONSTRATION PROJECT--TECHNICAL SUPPORT FOR PROJECT CONCEPT AND DEFINITION

Technical support shall be provided for Phase I, Project Concept and Definition, of the National Highway Traffic Safety Administration's (NHTSA) Motor Vehicle Diagnostic Inspection Demonstration Project. Phase I will develop extensive background information on automotive inspection equipment, procedures, and the repair process; will generate and deliver the required small garage equipment report to the Congress; and will identify promising concepts for next-generation, high-volume inspection facilities designed to interface closely with small repair shops. Under this contract, technical assistance will be given to the NHTSA by organizing a readily accessible data base which comprehensively characterizes those aspects of the commercial automotive repair process that significantly affect repair quality and cost. The data base shall be designed to assist in formulation of viable concepts for future diagnostic inspection systems and recommendations for Phase II project activity (System Design and Development). 00th

Transportation Consulting Division, Booz-Allen and Hamilton, Inc., 4733 Bethesda Avenue, Bethesda, Maryland 20014
$777,929.00
To be completed five hundred forty (540) days from date of contract award (8/10/77).

DOT-HS-7-01667

SEAT BELT ASSEMBLY ANCHORAGES

Seat belt assembly anchorages shall be tested in accordance with FMVSS No. 210 (National Highway Traffic Safety Administration's (NHTSA) Office of Standards Enforcement (OSE) Laboratory Test Procedure TP-210-05 dated January 31, 1977). 0y T

Dynamic Science, Inc., 1850 West Pinnacle Peak Road, Phoenix, Arizona 85027
Per Delivery Order
To be completed one (1) year from date of contract award (7/21/77).

DOT-HS-7-01668

SEAT BELT ASSEMBLY ANCHORAGES

Seat belt assembly anchorages shall be tested in accordance with FMVSS No. 210 (National Highway Traffic Safety Administration's (NHTSA) Office of Standards Enforcement (OSE) Laboratory Test Procedure TP-210-05 dated January 31, 1977).

Southwest Research Institute, 8500 Culebra Road, San Antonio, Texas 78284
Per Delivery Order
To be completed one (1) year from date of contract award (7/21/77).

DOT-HS-7-01669

MULTILEVEL STUDY OF ACCIDENT CAUSATION AND AVOIDANCE

Up-to-date statistics on the causes of accidents as they relate to countermeasures and special analyses in the accident avoidance area shall be provided for the Office of Statistics and Analysis (OSA) of the National Highway Traffic Safety Administration (NHTSA). The basic objectives of this contract are as follows: produce statistics on the relative roles of human, vehicular, and environmental factors in causing or increasing the severity of a specified, defined sample of nonfatal crashes involving at least one passenger car; produce statistics on significant and important over- (or under-) representations of various conditions, characteristics, and factors involved in the accidents as related to control, population-at-risk, exposure data; make accident avoidance assessments and determine potential effects of various vehicle sub-system improvements and driver evasive maneuvers in preventing or reducing the severity of accidents; separate causal factors from those that are known to be subject to certain countermeasures or modification by specified standards and those that are not (tabulate frequencies and associations); compare causal findings, where applicable, to the previous findings by Indiana University over the past five years and attempt to explain any significant or important differences; assess the methodologies and causal model(s) utilized in this study as to their amenability and compatibility with the NASS (National Accident Sampling System) concept and various known NASS methodologies at that point in time; and assess the representativeness of the causal data to the national experience to the extent possible (determine known biases in the data and adjust causal estimates appropriately). 0ccu

The Regents of the University of Michigan, 260 Research Administration Building - North Campus, Ann Arbor, Michigan 48109
$634,975.00
To be completed twenty-four (24) months from date of contract award (9/27/77).

DOT-HS-7-01508

TRAFFIC LAW SANCTIONS

The perceived severity of various traffic law sanctions and the relationship between sanctions and recidivism/incidence (at a given detection rate) for several jurisdictions shall be determined. An initial identification shall be made of at least six jurisdictions which differ only in type of sanction imposed (community work, contract, jail, fine, etc.) for driving offenses (unsafe driving acts (UDA's), multiple and serious offenses, DWI's (driving while intoxicated)). Three of these jurisdictions shall be selected and justified, one to represent each type of sanction application. Within each jurisdiction, the following tasks shall be accomplished: measure the perceived impact of sanctions vis-a-vis selected violations, analyze traffic records of drivers convicted of selected UDA's/Violations to compare recidivism rates among jurisdicions, and collect observational data regarding incidence of each violation.

PRC - Public Management Services, Inc., 7798 Old Springhouse Road, McLean, Virginia 22101
$202,456.00
To be completed twenty-four (24) months from date of contract award (7/28/77).

DOT-HS-7-01549 Mod. 3

LORAN DEMONSTRATION LABORATORY

The following additional tasks shall be accomplished: design and produce applications software for Loran Demonstration Laboratory (LDL) to be used in demonstrating Loran capabilities (and familiarize LDL personnel with the specific LDL demonstration configurations developed under this task); extend LDL capability through hardware and software modifications and additions (submit general design plans to the National Highway Traffic Safety Administration (NHTSA) prior to implementation of the new LDL features); and revise the LDL User's Guide to reflect changes and enhancement to the LDL.

The Mitre Corporation, METREK Division, 1820 Dolly Madison Blvd., McLean, Virginia 22101
Increased $9,995.00
Extended to 30 Sep 78

DOT-HS-7-01578

PEDESTRIAN INJURY CAUSATION PARAMETERS

In conjunction with the National Highway Traffic Safety Administration (NHTSA), Motor Vehicle Programs (MVP), development of an engineering position to support motor vehicle crashworthiness rule-making policies which would reduce fatalities and injuries resulting from motor vehicle/pedestrian accidents, the purpose of this contract is to increase the knowledge of vehicle/ pedestrian injury severity parameters to such extent that this will provide the basis for programs aimed at reducing the pedestrian injury severity. In the first phase of a two-phase effort, the following objectives shall be accomplished: organize a pedestrian-accident investigation team for one of three regional urban areas with field cooperation and staff to assure accurate collection of a representative sample of pedestrian/motor vehicle accidents involving passenger cars, pick-ups, and van vehicles less than 6000 lbs consistent with Phase 2 objectives. In the second phase, the following objectives shall be accomplished: identify those factors in pedestrian/motor vehicle accidents that are indicated statistically to be important in causing pedestrian injury severity; identify relationships between pedestrians, their injuries, and direct costs associated with pedestrian/vehicle accidents; and examine the feasibility of determing injury severity distribution and costs within the jurisdictions of the areas of the study (West and Far West Region, Southern Region, Central and Northeast Region), utilizing relations and correlations between police collectable data and more detailed accident investigations.

Calspan Corporation, Post Office Box 235, Buffalo, New York 14221
$223,369.00
To be completed thirty-six (36) months from date of contract award (4/18/77).

DOT-HS-7-01579

PEDESTRIAN INJURY CAUSATION PARAMETERS

In conjunction with the National Highway Traffic Safety Administration (NHTSA) Motor Vehicle Programs (MVP) development of an engineering position to support motor vehi-

cle crashworthiness rule-making policies which would reduce fatalities and injuries resulting from motor vehicle/pedestrian accidents, the purpose of this contract is to increase the knowledge of vehicle/ pedestrian injury severity parameters to such extent that this will produce the basis of programs aimed at reducing the pedestrian injury severity. In the first phase of a two-phase effort, the following objectives shall be accomplished: organize a pedestrian-accident investigation team for one of three regional urban areas with field cooperation and staff to assure accurate collection of a representative sample of pedestrian/motor vehicle accidents involving passenger cars, pick-ups, and van vehicles less than 6000 lbs consistent with Phase 2 objectives. In the second phase, the following objectives shall be accomplished: identify those factors in pedestrian/motor vehicle accidents that are indicated statistically to be important in causing pedestrian injury severity; identify relationships between pedestrians, their injuries, and direct costs associated with pedestrian/vehicle accidents; and examine the feasibility of determining injury severity distribution and costs within the jurisdictions of the areas of the study (West and Far West Region, Southern Region, Central and Northeast Region), utilizing relations and correlations between police collectable data and more detailed accident investigations.

Calspan Corporation, Post Office Box 235, Buffalo, New York 14221
$92,417.00
To be completed thirty-six (36) months from date of contract award (4/18/77).

DOT-HS-7-01580

PEDESTRIAN INJURY CAUSATION PARAMETERS

In conjunction with the National Highway Traffic Safety Administration (NHTSA) Motor Vehicle Programs (MVP) development of an engineering position to support motor vehicle crashworthiness rule-making policies which would reduce fatalities and injuries resulting from motor vehicle/pedestrian accidents, the purpose of this contract is to increase the knowledge of vehicle/ pedestrian injury severity parameters to such extent that this will provide the basis for programs aimed at reducing the pedestrian injury severity. In the first phase of a two-phase effort, the following objectives shall be accomplished: organize a pedestrian-accident investigation team for one of three regional urban areas with field cooperation and staff to assure accurate collection of a representative sample of pedestrian/motor vehicle accidents involving passenger cars, pick-ups, and van vehicles less than 6000 lbs consistent with Phase 2 objectives. In the second phase, the following objectives shall be accomplished: identify those factors in pedestrian/motor vehicle accidents that are indicated statistically to be important in causing pedestrian injury severity; identify relationships between pedestrians, their injuries, and direct costs associated with pedestrian/vehicle accidents; and examine the feasibility of determining injury severity distribution and costs within the jurisdictions of the areas of the study (West and Far West Region, Southern Region, Central and Northeast Region,) utilizing relations and correlations between police collectable data and more detailed accident investigations0t i

Southwest Research Institute, 8500 Culebra Road, San Antonio, Texas 78284
$209,978.00
To be completed thirty-six (36) months from date of contract award (4/18/77).

DOT-HS-7-01581

PEDESTRIAN INJURY CAUSATION PARAMETERS

In conjunction with the National Highway Traffic Safety Administration (NHTSA) Motor Vehicle Programs (MVP) development of an engineering position to support motor vehicle crashworthiness rule-making policies which would reduce fatalities and injuries resulting from motor vehicle/pedestrian accidents, the purpose of this contract is to increase the knowledge of vehicle/ pedestrian injury severity parameters to such extent that this will provide the basis for programs aimed at reducing the pedestrian injury severity. In the first phase of a two-phase effort, the following objectives shall be accomplished: organize a pedestrian-accident investigation team for one of three regional urban areas with field cooperation and staff to assure accurate collection of a representative sample of pedestrian/motor vehicle accidents involving passenger cars, pick-ups, and van vehicles less than 6000 lbs consistent with Phase 2 objectives. In the second phase, the following objectives shall be accomplished: identify those factors in pedestrian/motor vehicle accidents that are indicated statistically to be important in causing pedestrian injury severity; identify relationships between pedestrians, their injuries, and direct costs associated with pedestrian/vehicle accidents; and examine the feasibility of determining injury severity distribution and costs within the jurisdictions of the areas of the study (West and Far West Region, Southern Region, Central and Northeast Region), utilizing relations and correlations between police collectable data and more detailed accident investigations. 0ess

Traffic Safety Research Corporation, 1010 Corporation Way, Palo Alto, California 94303
$191,880.00
To be completed thirty-six (36) months from date of contract award (4/18/77).

DOT-HS-7-01608 IA

EVALUATION OF THE EFFECTIVENESS OF MEASURES FOR REDUCING ACCIDENTS AND ACCIDENT SEVERITY AT HIGHWAY NARROW BRIDGE SITES

The performance of on-scene (highway narrow bridge sites) accident investigations and reconstructions shall be modified. The following objective is added: investigate accident severity of collisions with bridge ends, railings and transition treatments to bridges using measures of delta "V", relative velocity and absorbed energy to determine its relationship between injury severity of motor vehicle accidents with bridges. Task B - 2b of Phase I shall be deleted in its entirety. The following shall be added in lieu thereof: develop a data collection plan

area(s) within eight sample States in which the on-scene investigations will be conducted. A representative distribution of different roadway facilities is required. Cooperation between the medical facilities shall be initiated. Task B-1 of Phase II shall be deleted in its entirety. The following shall be added in lieu thereof: investigate on-scene a minimum of 150 motor vehicle accidents involving bridges. At least 100 accidents should have as the first event in the collision sequence an impact to the bridge or to the guiding/protective device at the end of the bridge. Sample selection shall include those accidents where the vehicle is towed away from the scene. Task B-5 shall be added to Phase II and shall entail the following: design the field forms to be used in gathering the on-scene data. The investigation team shall be described in terms of the expertise, field accident reconstruction experience and methodology to be used in conducting the on-scene accident investigations. 0 da

DOT/Federal Highway Administration, Environmental Design and Control Division, Washington, D.C. 20590
$100,000.00
No change

DOT-HS-7-01617

DEVELOPMENT OF SPECIFICATIONS FOR PASSIVE BELT SYSTEMS

The objectives of the contract are to test the applicability in terms of comfort and convenience of recommended changes to FMVSS (Federal Motor Vehicle Safety Standard) 208 to passive safety belt systems; modify, improve, and/or verify these recommended changes; and provide a recommended standard that would provide front seat occupants with a passive belt system that is comfortable, convenient to use and acceptable to the consumer while providing optimum protection in the event of a crash.

Man Factors, Inc., 4433 Convoy Street, Suite E, San Diego, California 92111
$118,200.00
To be completed by 15 Jul 78.

DOT-HS-7-01620

CRITERIA FOR IMPLEMENTATION OF OPTIMUM INTEGRATION ALGORITHM INTO THE WRECKER PROGRAM

Criteria shall be established for an optimum temporal integration method for implementation into the National Highway Traffic Safety Administration's (NHTSA) WRECKER Program, a finite element program for analyzing the response of automobile structures under crash loading; and numerical runs shall be conducted to establish the comparative merits of candidate methods leading to a tentative recommendation. The WRECKER computer program employs a numerical integration algorithm in its solution procedure of the differential equations in the temporal variable. The precision, stability, and efficiency of this solution depend on the selection of the time integration algorithm. The following tasks shall be performed: conduct a literature search of the numerical integration algorithms used in the solution procedures of structural analysis programs; select three (3) candidate integration methods from 15 reviewed in the preceding task on the basis of cost, accuracy, stability, and applicability to crashworthiness-type problems, and implement these three methods into the solution procedure to create three (3) research versions of the WRECKER program; utilize the three (3) research versions to analyze component testing conducted for NHTSA by the University of Michigan (Contract DOT-HS-4-0085) and utilize other data to be provided to analyze the comparative merits of the selected integration algorithms for a variety of problem types; and analyze data from preceding task utilizing accuracy, stability and cost as minimum criteria. 0aus

"This contract is awarded by the Small Business Administration under the authority of Section 8(a) of the Small Business Act (USC 637a), and will be administered by the Department of Transportation, National Highway Traffic Safety Administration."
$47,795.36
To be completed twelve (12) months from date of contract award (6/27/77).

DOT-HS-7-01621

CORRELATION OF BRAKING SYSTEM DEFECTS & PERFORMANCE INSPECTION

A determination shall be made of whether or not a performance test device can accurately detect real-world automotive brake system defects and degradations that actually affect vehicle braking performance, and a determination shall be made of whether more than one test device can do the required testing and which test device is the most cost effective. The National Highway Traffic Safety Administration (NHTSA) research in the area of Vehicle-in-Use inspections of present day automotive braking systems has shown that there is a need for two distinct brake inspection techniques: visual inspection and performance testing. It is realized that a performance test will not detect all possible reject modes. It also [illegible] while the required instrumentation is part of the machine, not the vehicle, so as to minimize test time, cost, complexity and subjectivity. It is felt that any testing device may be a viable candidate to do the required performance inspection even if it is not an exact reproduction of a high speed, high torque stop if it detects those deficiencies in the braking system that do affect actual brake torque output. The following tasks shall be performed for this contract: review Contract DOT-HS-5-01188 wherein an experimental Torsion Bar Dynamometer was designed and built, and build two (2) of these full-size dynamometers and calibrate them according to test methodology of same contract; conduct tests using three (3) 1976 vehicles to compare brake torque output utilizing the torsion bar dynamometers, Bendix Dynamometer, Clayton High Speed Dynamometer and a platform brake tester, conduct tests to compare the ability of the various performance test devices to detect brake system defects or component degradation effects; and analyze test data by comparison of brake torque output for wheel hub transducers and test devices (dynamometer, platforms)

The University of Tennessee, Mechanical & Aerospace Engineering Dept., Knoxville, Tennessee 37916
$138,005.00
To be completed twelve (12) months from date of contract award (6/8/77).

DOT-HS-7-01628

VALIDATION AND APPLICATION OF THE WRECKER NONLINEAR FINITE ELEMENT PROGRAM IN ANALYZING VEHICLE SIDE STRUCTURES

The validation of the essential features of the National Highway Traffic Safety Administration's (NHTSA) WRECKER computer program in its application to the analysis of an automobile structure subjected to a crash environment shall be undertaken, and the computer program shall be applied to the analysis of an automobile structure subjected to a real-world crash environment. To achieve these goals, this program will parallel an experimental program (RFP No. NHTSA-6-A334) entitled "Lightweight Subcompact Vehicle Side Structures" and sponsored by NHTSA. The experimental program has the following objectives: to improve side structure integrity in vehicle-to-vehicle side impact collision, to improve occupant compartment integrity in vehicle-to-vehicle or vehicle-to-obstacle frontal offset collisions, and to establish structural improvements versus weight increases. Data from the experimental program and from previous compliance testing shall be used for validation of the computer program. It is recognized, however, that this validation is an initial effort and, therefore, shall be limited to specific loading conditions. The following simulations shall be pursued: the simulation of FMVSS No. 214, Compliance Test (pole into door structure), the simulation of 60 degree oblique collisions (static and dynamic) of the SAE (Society of Automotive Engineers) contoured barrier into the subcompact side structure, and the simulation of 60 degree oblique collisions of a 1965 selected vehicle model into the modified subcompact side structure. 0ali

ENSCO, INC., 5408A Port Royal Road, Springfield, Virginia 22151
$170,333.00
To be completed eighteen (18) months from date of contract award (6/13/77).

DOT-HS-7-01630

WINDSHIELD DEFROSTING AND DEFOGGING SYSTEMS

Windshield defrosting and defogging systems shall be tested in accordance with FMVSS No. 103 (National Highway Traffic Safety Administration's (NHTSA) Office of Standards Enforcement (OSE) Laboratory Test Procedure TP-103-09 dated July 2, 1976). The following exception to the test procedure shall be made: delete steps 4 through 8 of the Test Preparation (method of determining windshield layouts).

General Environments Corporation, 6840 Industrial Road, Springfield, Virginia 22151
Per Delivery Order
To be completed one (1) year from date of contract award (5/21/77).

DOT-HS-7-01631

WINDSHIELD DEFROSTING AND DEFOGGING SYSTEMS

Windshield defrosting and defogging systems shall be tested in accordance with FMVSS No. 103 (National Highway Traffic Safety Administration's (NHTSA) Office of Standards Enforcement (OSE) Laboratory Test Procedure TP-103-09 dated July 2, 1976). The following exception to the test procedure shall be made: delete steps 4 through 8 of the Test Preparation (method of determining windshield layouts). 0 th

Approved Engineering Test Laboratories, 1536 East Valencia Drive, P.O. Box 4158, Fullerton, CA 92631, Orange County
Per Delivery Order
To be completed one (1) year from date of contract award (5/21/77).

DOT-HS-7-01633

MOTORCYCLE HELMETS

Motorcycle helmets shall be tested in accordance with FMVSS No. 218 (National Highway Traffic Safety Administration's (NHTSA) Office of Standards Enforcement (OSE) Laboratory Test Procedure TP-218-00 dated March 1974). Off

Dayton T. Brown, Inc., Church Street, Bohemia, New York 11716
Per Delivery Order
To be completed twelve (12) months from date of contract award (5/27/77).

DOT-HS-7-01633 Delivery Order No. 1

MOTORCYCLE HELMETS

Seventy (70) tests of motorcycle helmets shall be conducted in accordance with FMVSS No. 218 (National Highway Traffic Safety Administration's (NHTSA) Office of Standards Enforcement (OSE) Laboratory Test Procedure TP-218-00 dated March 1974).

Dayton T. Brown, Inc., Church Street, Bohemia, New York 11716
$19,250.00
No change

DOT-HS-7-01634

MOTORCYCLE HELMETS

Motorcycle helmets shall be tested in accordance with FMVSS No. 218 (National Highway Traffic Safety Administration's (NHTSA) Office of Standards Enforcement (OSE) Laboratory Test Procedure TP-218-00 dated March 1974). 0 St

Southwest Research Institute, 8500 Culebra Road, San Antonio, Texas 78284
Per Delivery Order
To be completed twelve (12) months from date of contract award (5/27/77).

DOT-HS-7-01635

FIELD TEST OF A MOTORCYCLE SAFETY EDUCATION COURSE FOR NOVICE DRIVERS

In a three-phase effort, the determination of whether a new motorcycle safety evaluation course for novice riders is sufficiently promising to merit an evaluation of its accident reduction potential in a full-scale demonstration project, shall be accomplished. One of the factors contributing to the high motorcycle accident rate is lack of proficiency on the part of operators; statistics have shown that a very high proportion of accidents occur during the first 6 to 12 months of riding. The high accident rate characterizing the motorcycle rider's first year of operation suggests that a formal program of motorcycle safety education is needed. In 1976, as part of a cooperative agreement with the National Highway Traffic Safety Administration (NHTSA), the Motorcycle Safety Foundation (MSF) utilized specifications it had developed for motorcycle safety education to guide development of its new Motorcycle Rider Course, consisting of the materials (student texts, Instructor's Guide, visual aids, etc.) that are necessary to make an instructional program work. The instructional materials and the specifications were revised on the basis of a small pilot test in July-August 1976. The present contract is designed to accomplish the field test of the Motorcycle Rider Course. This shall be accomplished by incorporating the new course into the curriculum of a high school system so that at least 200 novice riders can be trained over a one-semester period. Phase I consists of Program Preparation; Phase II, Course Administration; Phase III, Data Analysis, Course Refinement, and Report Preparation. All activities that are required to evaluate instructional effectiveness, administrative feasibility, and user acceptance shall be performed.

Applied Science Associates, Inc., Box 158, Valencia, Pa.
059
03,460.00
) be completed by 15 Jul 78.

DOT-HS-7-01636

EXPERIMENTAL DATA FOR VALIDATING FINITE ELEMENT MODEL OF THORACIC SKELETAL RESPONSE

chniques and plans for obtaining experimental data from sh (i.e., unembalmed) human cadaver tests in support of ite element models of thoracic skeletal responses shall be fined, developed, demonstrated and employed. The functns of the data are to provide bases for the following purses: defining rib hard tissue failure and material properties; essing the effects on thoracic skeletal response of lung, of rcostal muscle and of visceral contents; and correlating dels of the rib alone and of the thoracic skeletal response h engineering structural response test data. The ultimate obive is to develop the capability for numerically simulating ually all vehicular crash problems and for predicting all sigcant injuries and internal biodynamic responses for any nan using finite element computer methods. 0ist

: University of Michigan, Division of Research
velopment & Admin., Research Admin. Bldg.-North
npus, Ann Arbor, Michigan 48105
2,620.00
be completed by 29 Jul 78.

DOT-HS-7-01637

LAMPS, REFLECTIVE DEVICES & ASSOCIATED EQUIPMENT

Lamps, reflective devices and associated equipment shall be tested in accordance with FMVSS No. 108 (National Highway Traffic Safety Administration's (NHTSA) Office of Standards Enforcement (OSE) Laboratory Test Procedure TP-108-06 dated September 11, 1975).

Industrial Testing Labs, Inc., 2813 Eighth Street, Berkeley, California 94710
Per Delivery Order
To be completed one (1) year from date of contract award (6/29/77).

DOT-HS-7-01638

LAMPS, REFLECTIVE DEVICES & ASSOCIATED EQUIPMENT

Lamps, reflective devices and associated equipment shall be tested in accordance with FMVSS No. 108 (National Highway Traffic Safety Administration's (NHTSA) Office of Standards Enforcement (OSE) Laboratory Test Procedure TP-108-06 dated September 11, 1975). 0oye

Ball Brothers Research Corporation, Post Office Box 1062, Boulder, Colorado 80303
Per Delivery Order
To be completed one (1) year from date of contract award (6/29/77).

DOT-HS-7-01639

LAMPS, REFLECTIVE DEVICES & ASSOCIATED EQUIPMENT

Lamps, reflective devices and associated equipment shall be tested in accordance with FMVSS No. 108 (National Highway Traffic Safety Administration's (NHTSA) Office of Standards Enforcement (OSE) Laboratory Test Procedure TP-108-06 dated September 11, 1975). 197

Electrical Testing Labs, Inc., 2 East End Avenue, New York, New York 10021
Per Delivery Order
To be completed one (1) year from date of contract award (7/29/77).

U.S. GOVERNMENT PRINTING OFFICE: 1978— 261-287:1